Implications of the state assistance program in the province of Quebec: the case of lamb production

Mosadegh Sedghy, Bahareh and Tamini, Lota D. and Lambert, Remy

10 November 2021

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Bahareh Mosadegh Sedghy, [1] Lota D. Tamini [2] and Rémy Lambert [3]

Abstract

This study investigated the impact of the Farm Income Stabilization Insurance (ASRA) on the adoption of price risk management strategies by lamb producers in the province of Quebec. This study employed a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) process to model price risks. The results indicated that the application of the Farm Income Stabilization Insurance in Quebec generates crowding-out effects on price risk management strategies, which decreases the efficiency of this program. On the other hand, the product-specific nature of ASRA leads to some challenges such as a modification in the revenue distribution across the farm, increased production, increased indebtedness of farmers and increased financial burden on governments' shoulders. Finally, the results imply asymmetric impacts of negative and positive shocks generated by ASRA which result in an increasing risk-aversion of producers over the periods of decreased prices and a decreasing risk aversion over the periods of increased prices.

Keywords

Crowding-out effects; ASRA; lamb production; Asymmetric GARCH; risk aversion; decoupled payments; Quebec; Relative marginal risk premium; state assistance programs; price volatility

[1] Corresponding author: bahareh.mosadeghsedg@uleth.ca, Dhillon School of Business, University of Lethbridge, 4401 University Dr W, Lethbridge, AB T1K 3M4 Canada.

[2] Lota.Tamini@eac.ulaval.ca, Department of Agricultural Economics and Consumer Science and Center for Research on the Economics of the Environment, Agri-food, Transports and Energy (CREATE), Universite Laval, 2425, rue de l'Agriculture, local 1122, Québec (Québec) G1V 0A6 Canada

[3] Remy.Lambert@eac.ulaval.ca, Department of Agricultural Economics and Consumer Science and Center for Research on the Economics of the Environment, Agri-food, Transports and Energy (CREATE), Universite Laval, 2425, rue de l'Agriculture, local 1122, Québec (Québec) G1V 0A6 Canada.

1. INTRODUCTION

The state assistance in the Canadian agricultural sector has a long history. The intention of state assistance programs is to help farmers manage the risks that threaten the agricultural sector and provide them with a reasonable and stable income. These programs were created upon the belief that the economic development of agriculture was contingent upon state intervention. This belief is justified by the low market power of farmers due to the perfect competition structure of agricultural markets, which in turn results in the declining trend of commodity prices relative to other prices and costs over time (Skogstad, 2008). Besides, many types of risk, specific to the agricultural sector (e.g. climate risk and disease breakout), lead to more volatility of farmers' income compared to that of producers in non- agricultural sectors. These specific characteristics of the agricultural sector prompted government intervention in this sector. The first state assistance legislation in the Canadian agricultural sector was the 1958 Agricultural Stabilization Act (ASA), intended to provide income support to producers in periods of depressed market returns. Western Grain Stabilization Act (WGSA) of 1976, the National Tripartite Stabilisation Program (NTSP)(1986), Gross Revenue Insurance Program (GRIP) (1991), Net Income Stabilisation Account (NISA)(1991), Income Disaster Assistance (AIDA) (1998) Canadian Agricultural Income Stability (CAIS) (2003) and business risk management programs (2007) are state assistance programs implemented in the Canadian agricultural sector (Antón et al., 2011). Besides, some provincial programs have been implemented to provide farmers with additional supports, with the intention of increasing the competitive advantage of farmers within the province. Among provincial programs, the Farm Income Stabilization Insurance (Assurance Stabilisation du Revenue Agricole, ASRA) has been implemented in the province of Quebec since 1975. The sectors supported by ASRA, which reached their peak in 2002, comprise fattened calves, steers, grain-fed calves, piglets, pigs, lambs, oats, wheat, corn, potatoes, milk calves, canola, barley, soybeans and apples. Under this program, the government compensates producers when the market price is below the production cost. Consequently, ASRA reduces losses associated with price risks.

This program has been subject to many criticisms. Critics believe that if the farm income risk is protected by the government, the farmers take more income risk producing more of the crop that tends to generate higher returns (Kimura and Anton, 2011). In other words, the implementation of risk-reducing policies decreases the sensitivity of farmers' production decisions to risk factors and reduces their incentive to employ risk management strategies. As a result, this response of farmers to risk-reducing policies decreases the efficiency of these policies. Several studies reveal shreds of evidence of the inefficiency of the ASRA. Mosadegh Sedghy et al. (2018) found that the implementation of ASRA in the province of Quebec, by affecting the sensitivity of farmers' production decisions to price risk, has led the corn production to be insensitive to price risks. Atozou & Lawin (2016) concluded that the implementation of ASRA in the Quebec pork industry leads producers to take more risk and increases the production regardless of the market situation. Rude and Surry (2014) concluded the implementation of ASRA in Quebec leads pork supply to be insensitive to input price risk. These studies contrast with previous studies concluding the significant and negative impact of price risk on the production of agricultural products in the absence of such distorting assistance programs (Holt, 1993; Ryan, 1977; Traill, 1978; Behrmann, 1968; Jordaan et al., 2007; Rezitis and Stavropoulos, 2008; Rezitis and Stavropoulos, 2010; Rezitis and Stavropoulos, 2012). The reduced sensitivity of production decisions to price risks following the implementation of ASRA decreases the efficiency of this program, as farmers replace their price risk management strategy (reduction of production) by benefiting from ASRA payments. In other words, ASRA generates crowding-out effects on risk management strategies. In another study, Gervais and Doyon (2004) concluded that the implementation of ASRA in the Quebec pork industry generates an incentive for farmers to sell their put options in periods that price expectations are higher than the target price. Thus, in this situation, the effectiveness of ASRA in reducing the variability of returns is decreased compared with the situation when producers use hedging instruments exclusively to manage price risk.

The purpose of this study is to investigate the crowding-out impact of ASRA on price risk management strategies of lamb producers in Quebec. The price risk is perceived as one of the most important risks in the agricultural sector due to the high volatility of agricultural input and output prices (Huchet-Bourdon, 2012; FAO, 2011). The program ASRA by compensating for negative price shocks is supposed to reduce farmers' production decision sensitivity to price risk. We expect that the implementation of ASRA reduces the motivation of producers to adopt price risk hedging strategies. Besides, we study the implications pf the implementation of ASRA in the Quebec lamb industry.

Our study focuses on the lamb industry in Quebec. The sheep and lamb industry in Canada is a small but important industry. In 2018, the lamb industry reached retail sales of US$725.7 million with volume sales of 23.2 million kilograms within Canada. Lamb represented a sales value market share of 3.9% of the overall retail Canadian meat (US$18.7 billion) sector (including lamb, beef, chicken, pork, turkey and other similar meat categories) (AAFC, 2019). The province of Quebec has a long history in sheep production with the first sheep arriving from France in the mid-1600s. The Quebec sheep industry has numerous organizations, which has helped in its development and growth over the last number of years (e.g. Quebec Purebred Association was founded in 1945, the Quebec sheep Federation was created in 1981 and the sheep research center founded in 1995). The lamb sector in Quebec is very well serviced by a large number of packing houses (39 registered abattoirs). The sheep dairy products industry in Quebec has a presence larger than most in Canada. There are currently 25 commercial processors permitted to handle sheep milk products in Quebec (CSF, 2019). Besides, the province of Quebec has a significant share of sheep and lamb production. In 2016, Quebec's lamb and sheep production consisted of 22% and 25% of the industry's total production and cash receipts respectively (Statistic Canada, tables 32-10-0155-01 and 3210-0045-01).

In this study, a Generalized Autoregressive Conditional Heteroskedasticity (GARCH) process is adapted to model price risks. Several empirical studies employed the GARCH model to investigate the impact of price risk on production decisions in the agricultural sector (Holt, 1993; Jordaan et al., 2007; Rezitis and Stavropoulos, 2008; Rezitis and Stavropoulos, 2010; Rezitis and Stavropoulos, 2012 and Mosadegh Sedghy et al., 2018).

Our study contributes to the literature by investigating the crowding-out effects of the ASRA on price risk management strategies in the Quebec lamb production sector. Consistent with the dynamics of agricultural prices a GARCH model is adopted to model price risks. In order to model the crowding-out effect of ASRA on price risk management strategies, price volatilities are incorporated in the supply function of lamb producers.

The rest of the paper is structured as follows. The second section presents the econometric model of the lamb supply and describes the data used. The third section explains the empirical results, and the final section presents the implications and conclusions of the study.

2. METHODOLOGICAL APPROACH AND DATA

In order to investigate the crowding-out effects of ASRA on risk management strategies, first, we examine the impact of ASRA on the sensitivity of lamb producers' production decisions to price risks. Then we analyze how the implementation of ASRA, would affect the employment of price risk hedging strategy. Following previous studies, we consider a reduction in production as the farmer's price risk hedging strategy when envisaging increased price volatility.

2.1. Supply Function

In this study, we employ the supply function driven by Rude and Surry (2014). The authors assume that producers have a constant absolute risk aversion and that the price distribution is normal. Under these conditions the objective function of the producer is:

$$MAX: P^e S \quad - C(\mathrm{S}) - \frac{\lambda}{2}\, s^2\, \mathrm{h^e} \tag{1}$$

Where P^e is the price expectation, h^e the price volatility, S the output supply, λ the absolute risk aversion parameter and $C(S)$ the cost function. By maximizing the producer's profit, Rude and Surry (2014) derived the following supply function:

$$S_t = \gamma_0 + \gamma_1 PO^e{}_t + \gamma_2 PI^e{}_t + \gamma_3\, h^{\mathrm{e}}_{Ot} + \gamma_4\, h^{\mathrm{e}}_{It} + \gamma_{5\mathrm{i}} \sum_{i=1}^{i} S_{t-i} + +\gamma_6 \mathrm{T_t} + +\gamma_{7\mathrm{i}} \sum_{j=1}^{12} M_{t-j} + \gamma_8 \mathrm{G_t} + \ w_{0t} \tag{2}$$

Where $PO^e{}_t$ is the expected price of the output, $PI^e{}_t$ the expected price of the input, h^e_{Ot} the output price volatility, h^e_{It} the input price volatility and w_{0t} the error term.

We assume that, in the long run, supply adjusts to its desired level (Nerlove, 1956). Thus, we incorporate lagged dependent variables ($\sum_i S_{t-i}$) in the model. Production lags imposed on the model are determined by the VARSOC method. This method reports the final prediction error (FPE), Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC), and the Hannan and Quinn information criterion (HQIC) lag order selection statistics for a series of vector auto-regressions of order 1 to maximum lag. A sequence of likelihood-ratio test statistics for all the full variables of the order less than or equal to the highest lag order is also reported. In the post-estimation version, the maximum lag and estimation options are based on the model just fit or the model specified in estimates (STATA). However, our tests suggest 3 lags in the model.

To capture the effect of technological progress, a trend variable (T_t) is incorporated in the model. Variables $\sum_i M_{t-i}$ are used to capture the monthly effect of lamb production. Finally, the dummy variable (G_t) is introduced to capture the effect of structural changes. These structural changes generated by the oil price increase since 2006, leads to a rise in agricultural prices (Baumeister and Kilian, 2014). The study of Avalos (2014) confirms the changes in dynamic of agricultural prices since 2006, which is related to oil price variations.

2.2. Price Expectation

Estimation of the supply function (equation 2) requires variables $PO^e{}_t$ and $PI^e{}_t$ to be generated. Following Rezitis and Stavropoulos (2010), we assume that prices follow an autoregressive process (AR):

$$P_t = \beta(L)P_t + w_{it} \quad (3)$$

$$w_{it}|\Omega_{t-1} \sim N(0, h_t)$$

Where $\beta(L)$ is a polynomial lag operator, P_t is the current price, w_{it} is an error term, where i captures the value of 1 and 2 when modelling output and input prices respectively, $\Omega_{t\text{-}1}$ is the information set of all past states available in period t-1 and h_t is the conditional variance of w_t. The general-to-specific method was used to determine the appropriate order of input and output prices. Consequently, the price equations are:

$$PO^e{}_t = PL^e{}_t = b_0 + b_1PL_{t-1} + b_2PL_{t-12} + b_3PL_{t-14} + w_{1t} \quad (4)$$

$$PI^e{}_t = PC^e{}_t = b_0'' + b_1''PC_{t-1} + w_{2t} \quad (5)$$

Where $PL^e{}_t$ and $PC^e{}_t$ represent lamb price expectation and corn price expectations respectively. Corn is considered as a major input in lamb production in Quebec, as it is the major source of energy in Quebec (Rude and Surry, 2014). Furthermore, Corn consists of 15% of the grain used in feeding lambs (CECPA, 2018).

2.3. Variance modelling

Unlike the other time series models, Generalized Autoregressive Conditional Heteroskedasticity models (GARCH) allow the conditional variance to vary over time, which is very relevant given the dynamics of agricultural prices. This characteristic of these models has led us to use GARCH models to model price volatilities. The results of the Lagrange Multiplier test applied to equations 4 and 5, reveal that the hypothesis of no ARCH effect can be rejected at the 0.10 level of significance (Tables A1 and A.2).

In order to capture the asymmetric effects of shocks generated by the ASRA on price volatilities, asymmetric GARCH models are used to model output and input price volatilities. These models allow positive and negative shocks to have different effects on price volatility. In the simple asymmetric GARCH model, the past values of the error term ($\sum_i w_{2(t-i)}$) are added to the equation of price variance to allow positive and negative shocks to have different effects on volatility.

The order of the GARCH model is determined by visual examination of the correlogram of squared residuals of the price equation and the results of the Ljung-Box (1976) Q test (Bollerslev, 1988), which lead us to the first-order Asymmetric Arch for modelling both lamb and corn price volatilities. Equations 6 and 7 explain the volatility of lamb and corn price respectively

$$h^e{}_{Ot} = h^e{}_{lt} = \alpha_0 + \alpha_1 w_{1(t-1)}^2 + \gamma_1 w_{1(t-1)} \tag{6}$$

$$h^e{}_{It} = h^e{}_{ct} = \alpha_0 + \alpha_1 w_{2(t-1)}^2 + \gamma_1 w_{2(t-1)} \tag{7}$$

Where $h^e{}_{lt}$ is the volatility of the lamb price and $h^e{}_{ct}$is the volatility of corn price.

The following restrictions are imposed to ensure that the conditional variance is strictly positive:

$$\alpha_0 > 0 \; and \; \alpha_i > 0$$

The stationarity of variance is guaranteed by $\sum_i \alpha_i = \alpha_1 < 1$ (Bollerslev, 1986).

2.4. Estimation Approach

Variables$P0^e{}_t$, $PI^e{}_t$, $h^e{}_{ot}$ and $h^e{}_{It}$ generated by the GARCH model can be used to estimate the equation 2. Pagan (1984) concluded that using variables generated by stochastic models to estimate a structural equation could produce biased estimates of standard deviations of parameters. One of the methods used to avoid this problem is the Full Information Maximum Likelihood (FIML) method. This method estimates the supply function, the price equation and the GARCH process parameters simultaneously. Considering the system of equations (8) the joint distribution of w_{0t} , w_{1t} and w_{2t} is written as follows:

$$\begin{gathered} S_t = \gamma_0 + \gamma_1 PL^e{}_t + \gamma_2 PC^e{}_t + \gamma_3 h^e{}_{lt} + \gamma_4 h^e{}_{ct} + \gamma_5 \sum_i S_{t-i} + + \gamma_{6\mathrm{i}} \sum_{j=1}^{12} M_{t-j} + w_{0t} \\ PL_t = b_0 + b_1 PL_{t-1} + b_2 PL_{t-3} + + b_3 PL_{t-12} + b_4 PL_{t-14} 4 + w_{1t} \\ PC_t = b_0'' + b_1'' PC_{t-i} + w_{2t} \end{gathered} \tag{8}$$

$$w_t = \begin{bmatrix} w_{0t} \\ w_{1t} \\ w_{2t} \end{bmatrix} \sim N \left[\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_{00} & \sigma_{01} & \sigma_{02} \\ \sigma_{01} & h_{lt} & \sigma_{12} \\ \sigma_{02} & \sigma_{12} & h_{ct} \end{bmatrix} \right] \tag{9}$$

Where $\begin{bmatrix} \sigma_{00} & \sigma_{01} & \sigma_{02} \\ \sigma_{01} & h_{lt} & \sigma_{12} \\ \sigma_{02} & \sigma_{12} & h_{ct} \end{bmatrix} = \prod_t$ represents the variance-covariance matrix

The log-likelihood function of the above system is given as follows:

$$l_T(\Theta) = 0.5 \sum_{t=1}^{T} l_t(\Theta) \tag{10}$$

$$l_t(\Theta) = -log \left| \prod{}_t \right| - \mathcal{E}'_t \prod{}_t^{-1} \mathcal{E}_t \tag{11}$$

2.5. Relative marginal risk premium index (RRP)

For the purpose of analyzing the risk-averse behaviour of lamb producers in Quebec, we estimate the Relative marginal Risk Premium (RRP) index. This index is determined by the negative of the ratio of the variance and the price elasticity of supply (Holt and Moschini, 1992).

$$RRP_t = -\frac{\gamma_3}{\gamma_1} \cdot \frac{h_t^e}{P_t^e} \tag{12}$$

The positive value of this index implies the risk aversion behaviour of lamb producers rather than risk neutrality behaviour (Rezitis and Stavropoulos, 2010). The greater the value of RRP is, the greater the producer responds to price volatility rather than to price expectations.

2.6. Data

Our analyses cover the period of 2000 to 2014, and the supply model is based on monthly data. Data on the number of slaughtered lambs (output supply) were provided by Agriculture and Agri-Food Canada.[4]

Lamb prices (expressed in dollars per hundred kilograms) are monthly average prices for 100 animals. These data are obtained from Agriculture and Agri-Food Canada.[5] The effective prices are built by adding compensation from the Farm Income Stabilization Insurance Program (ASRA)

[4] https://aimis-simia.agr.gc.ca/rp/index-eng.cfm?action=sR

[5] http://www.agr.gc.ca/redmeat/sla-aba_fra.htm

to market prices. Compensation values are gathered from the "*La Financière agricole*" (provincial government agency) website.[6]

Corn is used as an input of lamb production. Corn prices are obtained from Statistics Canada.[7] Following Rezitis and Stavropoulos (2010), all prices are deflated by the consumer price index (2002 = 100).

Table (1) presents some statistics on the data used in the analyses.

<<< Table1 about here >>>

3. RESULTS

Table 2 provides the results of the unit root tests, namely the Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) tests.

<<< Table2 about here >>>

Table 2 indicates that all the variables are stationary.

3.1. Price Analysis

The estimation results of lamb price equations are presented in table 3.

<<< Table 3 about here >>>

[6] http://www.fadq.qc.ca/fr/statistiques/assurance-stabilisation/historique-par-produit-dassurance/

[7] Table 002-0043

The results indicate that the coefficients of lagged values of the price (b_1, b_2 and b_3) of output are significant at the 5 % level.

The coefficient of the conditional variance of lamb price expressed by α_1 is significant and values less than unity, which indicates time-varying and persistent volatility. The coefficient of asymmetry factor expressed by γ_1 is significant, which confirms the presence of asymmetric effects of shocks on lamb price volatility. The positive sign of γ_1 indicates that a positive shock in price causes more volatility than negative shocks of the same magnitude, which implies a strong position of lamb producers in Quebec resulted from the implementation of ASRA. Since ASRA compensates for negative price shocks, producers are able to benefit from the unexpected positive shocks of demand, and they need not decrease their prices in case of negative demand shocks (Rezitis and Stavropoulos, 2010).

Finally, the Ljung-Box Q statistic test was applied to the residuals (w_{1t}) and the squared residuals (w_{1t}^2) of the lamb price equation to analyze the performance of the model. The results of this test on w_{1t} and w_{1t}^2 support the non-rejection of the hypothesis that the residuals and squared residuals of the lamb price equation are white noise.

Table 4 presents the estimated parameters of the corn price

<<< Table 4 about here >>>

According to the results, the coefficient of the lagged value of the price (b_1'') is significant at the 1% level. The coefficient of the conditional variance expressed by α_1 is significant, which indicates time-varying volatility. Furthermore, $\alpha_1$values less than unity, implying persistent volatility. The coefficient of the asymmetry factor of shocks (γ_1) is significant at 1%, which confirms the presence of an asymmetric effect of shocks on volatility.

Finally, the Ljung-Box Q statistic test was applied to the residuals (w_{2t}) and the squared residuals ($w^2{}_{2t}$) of corn price equations to analyze the performance of the model. The results of this test on w_{2t} and $\mathrm{w}^2{}_{2t}$ support the non-rejection of the hypothesis that the residuals of the input price equations are white noise, while the autocorrelation between squared residuals of the model is one of the implications of the GARCH effect in prices (Bollerslev 1987). The application of an appropriate order of GARCH removes the correlation of squared residuals (Giannopoulos, (1995)). The Ljung-Box test applied to residuals and squared residuals of the SAARCH model indicates the absence of autocorrelation between the residuals and squared residuals.

3.2. Supply Response

3.2.1. Results

A Maximum Likelihood method was used to estimate the structural model equations. The application of Harvey and Guilkey's test confirms the good performance of the model (Table A3). Besides, the application of the Ljung-Box Q statistic test, affirms that there is no autocorrelation between residuals and squared residuals in the model (Table 5).

Table 5 presents the results of the estimation of the structural model.

<<< Table 5 about here >>>

The coefficient of the expected price of lamb (γ_1) has a positive sign, as predicted. However, the coefficient of the expected price of corn (γ_2) is negative, implying a decrease in the lamb supply following an increase in the input price, which is also predicted. The negative sign of the coefficient of output and input price volatility (γ_3 and γ_4 respectively) implies that supply responds negatively to an increase in volatility. These results are consistent with prior studies (e.g. Holt and Aradhyula, 1990; Holt, 1993; Rezitis and Stavropoulos, 2008; Rezitis and Stavropoulos, 2010 and Rude and Surry, 2014).

The coefficients γ_{51}- γ_{53} capture the effects of supply adjustment in lamb supply. The variables $\gamma_{71} - \gamma_{712}$ are used to capture the monthly effects of supply.

The results illustrate the significant effect of the output price expectations and output price volatility on lamb supply. However, the results demonstrate the significant impact of input price expectation whereas the non-significant effect of input price volatility on the lamb supply. These results are consistent with the studies of Mosadegh Sedghy et al. (2018) and Rude and Surry (2014) conducted in the corn and pork markets of Quebec respectively. These authors found that the corn and pork supply, which are covered under ASRA, are insensitive to input price volatility

3.2.2. Discussion

The insensitivity of the supply of products covered under ASRA to input prices is not surprising since ASRA compensates producers for unpredictable increases in production costs. On the other hand, the insensitivity of supply to input price risk resulted from the application of ASRA, implies that farmers do not perceive the input price risk. As a result, they do not take the hedging strategy of supply reduction against increased input price risk. Consequently, the implementation of ASRA leads to increased production regardless of market conditions (Atozou & Lawin, 2016), which would impose a burden on the government to cover an increased amount of supply under ASRA.

The programs such as ASRA that are linked to the production of specific commodities or livestock, affect the production decisions of farmers by motivating actual producers to increase their production and potential producers to join the industry. These programs significantly modify the distribution of revenue and income of the farm and therefore modify the whole production and risk management strategy of the farmer (OECD 2009).

Moreover, an increase in production requires an increase in investment in farm operations, which in turn increases the indebtedness of producers. As evidence, an increase of 13% (from 28.4% in 2004 to 32.2%) in the debt ratio of agricultural enterprises in Quebec has been observed in 2005, whereas this ratio stood at 20.4% in Ontario and 11.4 % in the US (Pronovost, 2008).

It seems that the efficiency of ASRA in increasing the welfare of farmers is reduced by generating the crowding-out effect. Following the implementation of ASRA, farmers stop adopting their own price risk hedging strategy (reduction in production) taking ASRA as a substitute for risk management strategy. Furthermore, since ASRA is linked to the production of some specific commodities and livestock, it modifies production decisions so that the efficiency of these decisions is not guaranteed. The later could be solved by replacing ASRA by decoupled payments.

3.3. Supply elasticities

3.3.1. Results

The introduction of the lagged value of output in the model (see equation 2) allows us to calculate both the long-term and short-term supply elasticities.

The estimations reveal the lamb supply elasticity relative to expectations of the lamb price at 0.18 in the short term and 0.26 in the long term, and relative to lamb price volatility at 0.17 in the short term and 0.24 in the long term. Lamb supply elasticity relative to input price expectations was estimated at 0.1 in the short term and 0.15 in the long term.

3.3.2. Discussion

Estimations of lamb supply elasticity relative to expectations of the lamb price (0.18 in the short term and 0.26 in the long term) and relative to lamb price volatility (0.17 in the short term and 0.24 in the long term) confirm the Le Chatelier principle (Samuelson, 1947). The Le Chatelier principle implies that long-term elasticities of supply and demand are more important than short-term elasticities. These estimations imply more sensitivity of lamb supply to lamb prices than to lamb price volatility since the ASRA by compensating farmers for price shocks decreases the sensitivity of supply to price risks. Moreover, the results of our estimation of the lamb supply elasticity relative to the output price in the short-term (0.18) are consistent with that estimated by Rude and Surry (2014) for pork supply in Quebec (0.2), implying similar sensitivity of lamb and pork supply to output price expectations.

However, the sensitivity of the lamb supply to output price expectations and volatility is decreasing over time (Figure 1). This result accompanied by the increasing trend of production (Figure 2) confirms the results of Atozou & Lawin's (2016) study, which implies that ASRA is driving the sustained increase in production regardless of market conditions.

Estimation of supply elasticity relative to input price expectations (0.1 in the short term and 0.15 in the long term) demonstrates more sensitivity of supply to output prices than to input prices. Several reasons may explain this result. First, the gap between the production decision and the purchase of inputs is shorter than that between production decisions and marketing (Nijs, 2014). Second, input prices are positively correlated to the price of outputs, as an increase in input prices thus will be reflected in output prices. Further, the input price as a component of production cost is compensated by ASRA, which makes supply less sensitive to input price expectations than to output price expectations.

On the other hand, a comparison between price elasticity of lamb supply, pork supply (estimated by Rude and Surry (2014)) and that of corn supply (0.5) estimated by Mosadegh Sedghy et al. (2018) for the same period indicates that corn supply is more sensitive to price expectation than lamb and pork. It can be explained by the storability of grains as available stocks make the supply more elastic (FAO).

Figure 1: Lamb supply elasticity relative to lamb price expectations and lamb price volatility (2001-2013)

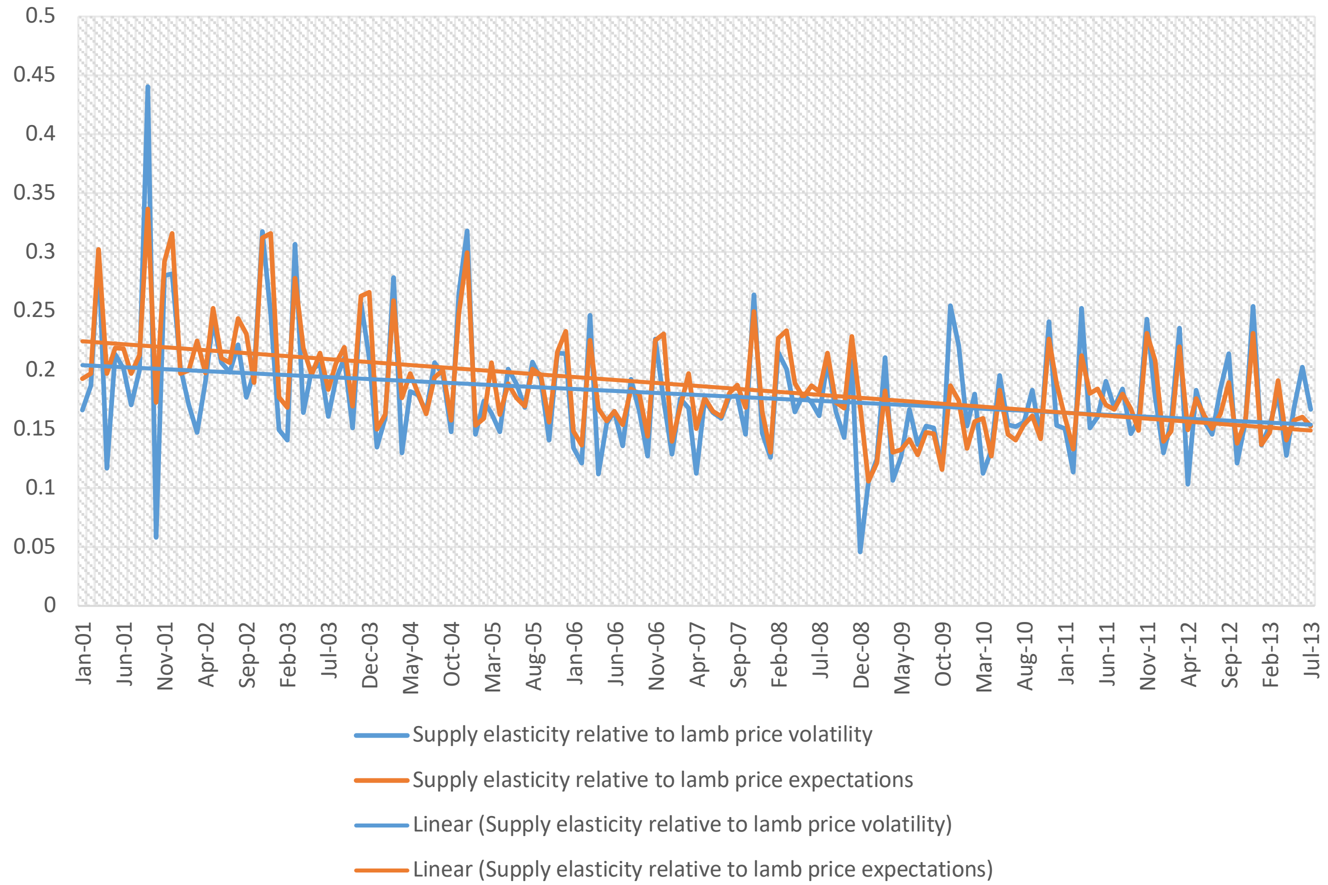
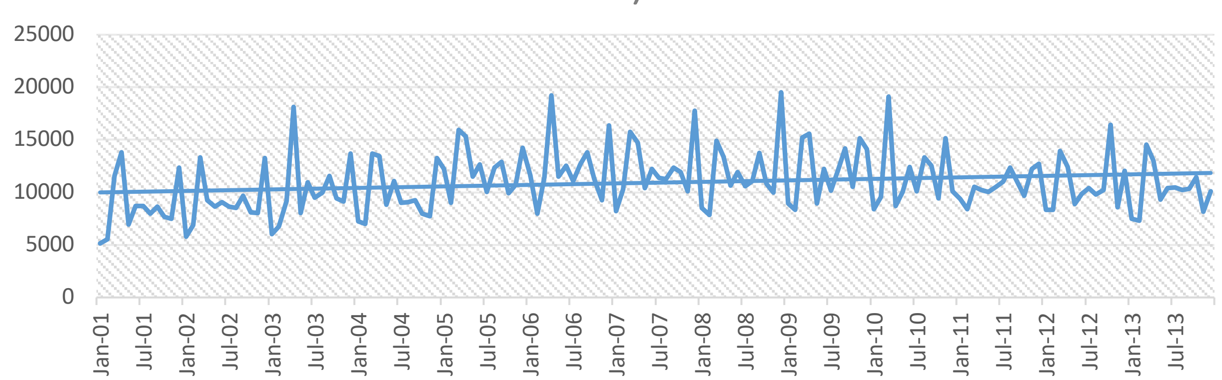


Figure 2: Lamb supply in the province of Quebec (2001-2013)



3.4. Relative Marginal Risk Premium Index

Finally, we analyzed the risk-averse behaviour of lamb producers in Quebec by estimating the Relative marginal Risk Premium (RRP). This index can be defined as the relative sensitivity of supply to lamb price volatility and lamb price expectations. In other words, the greater the value of RRP is, the greater the producer responds to price volatility rather than to price expectations.

The estimation of this index at each point in time demonstrates the risk-averse behaviour of lamb producers versus price volatility, as they respond to lamb price volatility by reducing their production. The estimated index ranges from 0.27 to 1.36 with an average of 0.95 in the investigated period. However, the increasing trend of this index (Figure 3) implies the increasing perception of producers of the importance of lamb price volatility relative to lamb price expectations over time.

This result is justified by the decreasing trend of lamb price expectations and volatility (Figure 4)[8]. Implementation of ASRA leads positive and negative shocks to have different impacts on supply. Since ASRA compensates for negative price shocks, in periods of decreasing prices producers do not reduce their production as much as they increase it in periods of increasing prices. In the same way, in the periods of increasing prices and volatility, producers do not decrease the production as much as they increase it in the periods of decreasing volatility. As a result, when prices and volatility both have a decreasing trend, the sensitivity of supply to volatility is more than that to prices.

[8] For the purpose of increasing the quality of the figure, all prices are divided by 10. Since the intention is to show the trend, this division does not affect the conclusion.

Figure 3: Relative Marginal Risk Permium

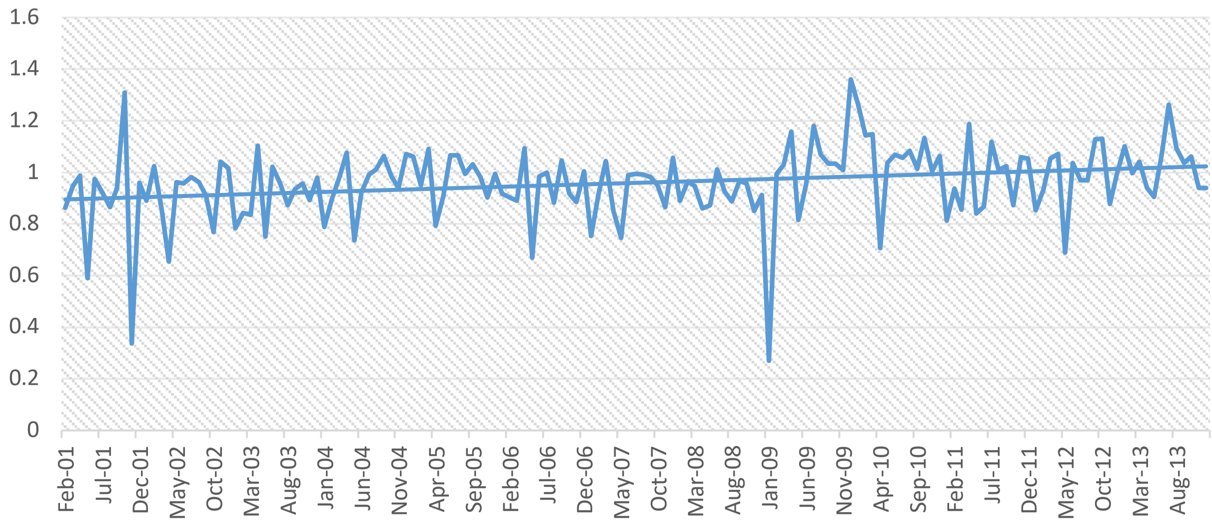
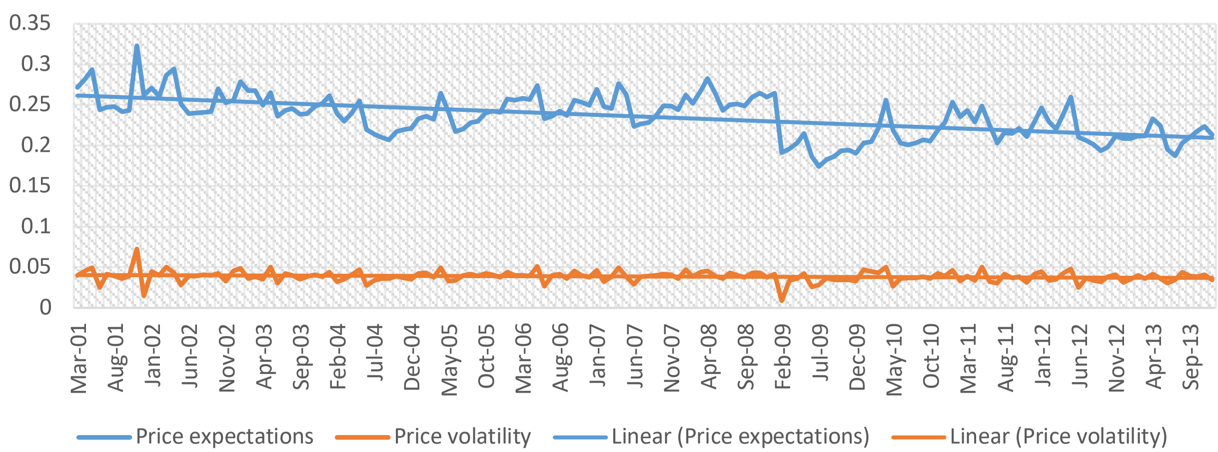


Figure 4: Price expectations and price volatility trends



CONCLUSION

This study investigates the efficiency and implications of the Farm Income Stabilization (ASRA) program in managing the lamb price risk in Quebec. For these purposes, we estimate the supply function of lamb by incorporating the price risk factor in it. Asymmetric GARCH models are used to model input and output price risks.

The results reveal that the efficiency of ASRA is reduced by generating a crowding-out effect on risk management strategies. As ASRA compensates farmers for production costs, it leads lamb producers' production decisions to be insensitive to input price risk. This insensitivity of supply to input price risk implies that farmers stop hedging input price risk while substituting ASRA for their risk management strategy. Based on the results of the study, this crowding-out effect increases over time so that the sensitivity of lamb supply to both lamb price expectations and lamb price volatility decreases over the period of the study.

Furthermore, since ASRA is specific to some commodities and livestock, it provides farmers with an incentive to increase the production of products covered under ASRA. Consequently, ASRA modifies the distribution of revenue across the farm and leads to increased production regardless of market conditions. The impact of increased production following the implementation of ASRA is twofold: first, it imposes an extra burden on governments' shoulders to cover higher amounts of the commodity or livestock and second, it leads to an increase in indebtedness of farmers since an increase in production requires increased investment.

On the other hand, the implementation of ASRA generates asymmetric effects of price shocks on lamb supply. As ASRA compensates negative price shocks, producers respond to price increases more than price decreases. This result has different implications in the periods of decreased and increased prices. In the periods where price expectations and price volatilities both are decreasing, supply is more sensitive to price volatility than to price expectations. In this situation, decreased price volatility provides the producer with an incentive to increase production. However, ASRA payments leave fewer incentives for producers to respond to decreased prices as much as they respond to decreased price volatility. An inverse is observed in the periods of increased price expectations and volatility where supply is more elastic to price expectations than to price volatility.

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TABLE 1. Data statistics

Variable	Unit	Minimum	Maximum	Mean	Standard deviation
PC (Corn price)	Dollars per tonne	1.7	0.99	3.03	0.41
SL (Lamb supply)	Number of slaughtered lambs	4466	21258	12161	3000
PL (Lamb price)	Dollars per hundred quintal	104	301	164	34

TABLE 2. Unit root test

	The model with intercept and without trend		The model with intercept and trend	
	Augmented Dickey-Fuller (ADF)	**Philips-Perron (PP)**	**Augmented Dickey-Fuller (ADF)**	**Philips-Perron (PP)**
PC	-4.036[a]	-3.715[a]	-3.992[a]	-3.680[c]
SL	-3.6[a]	-11.25[a]	-3.95[b]	-12.24[a]
PL	-2.3[c]	-5.05[a]	-3.2[c]	-6.39[a]

*a significant at 0.01 * b significant at 0.05 * c significant at 0.10

TABLE 3. Results of the lamb price equation

Parameter	Variable	Coefficient
	Conditional mean	
b_0	1	0.41(0.02)
b_1	First price lag	0.77(0.00)
b_2	Twelfth price lag	0.22(0.00)
b_3	Fourteenth price lag	-0.17(0.02)
	Conditional Variance	
α_0	1	0.034(0.00)
$\alpha 1$	$w^2_{2(t-1)}$	0.000(0.00)
γ_1	$w_{2(t-1)}$	0.038(0.01)
Test of price equation's residual generated by the autoregressive (AR) model (w_{1t})		
Q(6)		3.4 (0.75)
Q(12)		7.09 (0.85)
Q(18)		12.6 (0.81)
Q(24)		26.97 (0.31)
$Q^2(6)$		5.12 (0.53)
$Q^2(12)$		6.04 (0.91)
$Q^2(18)$		8.38 (0.97)
$Q^2(24)$		9.18 (0.99)
Test of price equation's residual generated by the GARCH model		
Q(6)		3.56 (0.74)
Q(12)		6.56 (0.88)
Q(18)		11.59 (0.87)
Q(24)		25.02 (0.40)
$Q^2(6)$		9.01 (0.17)
$Q^2(12)$		10.2 (0.60)
$Q^2(18)$		12.75 (0.81)
$Q^2(24)$		13.83 (0.95)

Figures in brackets are p-values

TABLE 4. Results of the corn price equation

Parameter	Variable	Coefficient
		Conditional mean
b''_0	1	0.43(0.00)
b''_1	First price lag	0.85(0.00)
		Conditional Variance
α_0	1	0.02(0.00)
$\alpha 1$	$w^2_{2(t-1)}$	0.30(0.00)
γ_1	$w_{2(t-1)}$	0.12(0.00)
Test of price equation's residual generated by the autoregressive (AR) model (w_{2t})		
Q(6)		5.57 (0.47)
Q(12)		15.86 (0.20)
Q(18)		20.14 (0.32)
Q(24)		31.13 (0.15)
$Q^2(6)$		8.94 (0.18)
$Q^2(12)$		30.64 (0.002)
$Q^2(18)$		37.90 (0.004)
$Q^2(24)$		48.82 (0.002)
Test of price equation's residual generated by the GARCH model		
Q(6)		6.00 (0.42)
Q(12)		12.17 (0.43)
Q(18)		15.20 (0.65)
Q(24)		28.65 (0.23)
$Q^2(6)$		3.24 (0.77)
$Q^2(12)$		21.20 (0.26)
$Q^2(18)$		13.92 (0.73)
$Q^2(24)$		31.42 (0.14)

Figures in brackets are p-values

TABLE 5. Results of supply response		
Parameter	**Variable**	**Coefficient**
γ_0	1	11388.24 (0.000)
γ_1	Output price expectation	838.48 (0.006)
γ_2	Input price expectation	-1656.10 (0.034)
γ_3	Output price volatility	-48824.49 (0.087)
γ_4	Input price volatility	-1227.38 (0.786)
γ_{51}	S_{t-1}	-0.73 (0. 36)
γ_{52}	S_{t-2}	-0.38 (0.63)
γ_{53}	S_{t-3}	0. 27 (0.000)
γ_6	T_t	5.51 (0.457)
γ_{71}	M_1	-2492.6(0.080)
γ_{72}	M_2	-3800.42 (0.015)
γ_{73}	M_3	297.25 (0.849)
γ_{74}	M_4	2671.66 (0.083)
γ_{75}	M_5	-1201.21(0.447)

γ_{76}	M_6	-1830.08 (0.248)
γ_{77}	M_7	-2757.20 0.073)
γ_{78}	M_8	-887.90 (0.56)
γ_{79}	M_9	-710.34 (0.640)
γ_{710}	M_{10}	-1167.84 (0.441)
γ_{711}	M_{11}	-1726.87 (0.260)
γ_{712}	M_{12}	834.60 (0.562)
γ_8	G	1477.16 (0.020)
Q(6)	3.50 (0.74)	
Q(12)	13.06 (0.36)	
Q(18)	19.37 (0.37)	
Q(24)	28.38 (0.24)	
Q^2 (6)	4.56 (0.60)	
Q^2 (12)	10.04 (0.61)	
Q^2 (18)	10.44 (0.92)	
Q^2 (24)	17.82 (0.81)	

Appendix

Table A1. Lagrange Multiplier Test (ARCHLM) for lamb prices

Chi2	Degrees of freedom	Prob>chi2
3.493	1	0.06

Null hypothesis: No ARCH effect   Alternative hypothesis: ARCH(p) disturbance

Table A2. Lagrange Multiplier Test (ARCHLM) for corn prices

Chi2	Degrees of freedom	Prob>chi2
40.59	1	0.000

Null hypothesis: No ARCH effect   Alternative hypothesis: ARCH(p) disturbance

Table A3. Harvey and Guilkey autocorrelation test applied to lamb supply

	Harvey LM test	Rho	Pvalue>chi 2
Single Equation Autocorrelation Tests			
Supply equation	0.168	0.001	0.68
Corn price equation	0.039	0.0002	0.84
General SEM autocorrelation test			
Harvey	0.20		0.9
Guilkey	2.5		0.62

Rho: Correlation coefficient

Null hypothesis: No Autocorrelation

REFERENCES

- Antón, J., Kimura, S., & Martini, R. (2011). Risk management in agriculture in Canada.
- Atozou, B., & Lawin, K. G. (2016). Impact of the Farm Income Stabilization Insurance Program on Production Decisions in the Quebec Pork Industry: An Empirical and Theoretical Analysis. Sustainable Agriculture Research, 5(526-2017-2652).
- Avalos, F. (2014). Do oil prices drive food prices? The tale of a structural break. Journal of International Money and Finance 42: 253-271.
- Baumeister, C. and L. Kilian. (2014). Do oil price increases cause higher food prices? Economic Policy 29(80):691-747.
- Behrman, J. R. 1968. Supply response in underdeveloped agriculture; a case study of four major annual crops in Thailand, 1937-1963.
- Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. Journal of Econometrics 31(3): 307-327.
- Bollerslev, T. (1987). A conditionally heteroskedastic time series model for speculative prices and rates of return. The Review of Economics and Statistics. 69(3): pp 542-547.
- Bollerslev, T. (1988). On the correlation structure for the generalized autoregressive conditional heteroskedastic process. Journal of Time Series Analysis 9(2): 121-131.
- FAO. (2011). L'état de l'insécurité alimentaire dans le monde: Comment la volatilité des cours internationaux porte-t-elle atteinte à l'économie et à la sécurité alimentaire des pays? Rome, Italy.
- Gervais, J. P., & Doyon, M. (2004). Developing hedging strategies for Quebec hog producers under revenue insurance. Canadian Journal of Agricultural Economics/Revue Canadienne d'agroeconomie, 52(1), 35-53
- Giannopoulos, K. (1995). Estimating the time varying components of international stock markets' risk. The European Journal of Finance 1(2): 129-164.
- Holt, M. T. (1993). Risk response in the beef marketing channel: A multivariate generalized ARCH-M approach. American Journal of Agricultural Economics 75(3): 559-571.
- Holt, M. T. and G. Moschini. (1992). Alternative measures of risk in commodity models: An analysis of sow farrowing decisions in the United States. Journal of Agricultural and Resource Economics 17(1):1-12.
- Holt, M. T. and S. V. Aradhyula. (1990). Price Risk in Supply Equations: An Application of GARCH Time-Series Models to the US Broiler Market. Southern Economic Journal 57(1):230-242
- Huchet-Bourdon, M. (2012). Est-ce que la volatilité des prix des matières premières agricoles augmente? Une étude historique. Éditions OCDE.
- Jordaan, H., Grove, B., Jooste, A., & Alemu, Z. G. (2007). Measuring the price volatility of certain field crops in South Africa using the ARCH/GARCH approach. Agrekon, 46(3), 306-322.
- Kimura, S., & Anton, J. (2011). Farm income stabilization and risk management: Some lessons from AgriStability program in Canada (No. 726-2016-49783).

- Mosadegh Sedghy, B., Tamini, L. D., & Lambert, R. (2018). Effects of price insurance programs on supply responses: a case study of corn farmers in Quebec.
- Nerlove, M. (1956). Estimates of the elasticities of supply of selected agricultural commodities. Journal of Farm Economics 38(2):496-509.
- Nijs, L. (2014). The Handbook of Global Agricultural Markets: The Business and Finance of Land, Water, and Soft Commodities. Palgrave Macmillan.
- Organisation for Economic Co-operation and Development (OECD). (2009). Managing risk in agriculture: a holistic approach. OECD publishing.
- Pagan, A. 1984. Econometric issues in the analysis of regressions with generated regressors. International Economic Review 25(1) 221-247.
- Pronovost. J. (2008). Agriculture et Agroalimentaire : Assurer et Bâtir L'avenir. Rapport de la Commission sur l'avenir de l'agriculture et de l'agroalimentaire québécois.Retrieved from http://www.caaaq.gouv.qc.ca/userfiles/file/dossiers%2012%20fevrier/rapportfr_haute.pdf
- Rezitis, A. and K. Stavropoulos, (2008). Supply Response and Price Volatility in the Greek Pork Industry. International Conference of Applied Economics.
- Rezitis, A. N. and K. S. Stavropoulos. (2010). Modeling beef supply response and price volatility under CAP reforms: the case of Greece. Food policy 35(2): 163-174.
- Rezitis, A. N., & Stavropoulos, K. S. (2012). Greek meat supply response and price volatility in a rational expectations framework: a multivariate GARCH approach. European Review of Agricultural Economics, 39(2), 309-333.
- Rude, J. and Y. Surry. (2014). Canadian Hog Supply Response: A Provincial Level Analysis. Canadian Journal of Agricultural Economics/Revue canadienne d'agroéconomie 62(2): 149-169.
- Ryan, T. J. (1977). Supply response to risk: The case of US pinto beans. Western Journal of Agricultural Economics 2:35-43.
- Samuelson, P. A. (1947). Foundations of economic analysis. Harvard University Press
- Seale, J. L., & Shonkwiler, J. S. (1987). Rationality, price risk, and response. Journal of Agricultural and Applied Economics, 19(1), 111-118.
- Skogstad, G. (2008). Internationalization and Canadian agriculture: Policy and governing paradigms (Vol. 30). University of Toronto Press.
- Traill, B. 1978. Risk variables in econometric supply response models. Journal of Agricultural Economics, 29(1):53-62.

Online References

- AAFC. (2019). Customized Report Services – Market Overview: Canadian lamb and sheep meat and product trends Retrieved 2020/02/28 from http://www.agr.gc.ca/eng/canadian-agri-food-sector/canadian-agri-food-sector-intelligence/customized-report-services-market-overview-canadian-lamb-and-sheep-meat-and-product-trends/?id=1572363678407#b
- CECPA. (2018). Indexation 2018: secteur agneaux Retrieved 2020/02/28, from https://www.cecpa.qc.ca/?rub=2&sousRub=1&typeProduction=9

- CSF. (2019). First Annuall Global Sheep Conference. Retrieved 2020/2/28 from https://www.cansheep.ca/documents/2019ConferenceProceedingsFINALPDF.pdf?fbclid=IwAR0F6KmKjBQu3mOpugeVD3VlKG80MHvRn2sO1QIk--sTvSkllJ054Osx9dg

- FAO. Market Assessment and Analysis: Elasticity of Supply and Demand Retrieved 2020/02/28, from https://l.facebook.com/l.php?u=http%3A%2F%2Fwww.fao.org%2Felearning%2FCourse%2FFM%2Fen%2Fpdf%2FElasticity.pdf%3Ffbclid%3DIwAR0m8wBl7kSth2f18-ttiknwrVFOLwaXTNRe7jTynW9KhtJN98GExnYOGX8&h=AT2Pt2C-PDUu7wKEt--DD_wAKz_AyUzKnT7eO-WakhU5IHI1MV3wLNc3-lfZlYDYH9JDIepfKAIGPRO-gCTlPCHKA3H1fxaL-s_ZcS4W6ngSTGxD5h_bQJEyx8xFKq7-uuSNnA

- STATA. VARSOC. Retrieved 2020/02/28, from STATA manuals, https://www.stata.com/manuals13/tsvarsoc.pdf