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DETECTING COOL IMPACTS ON U.S.- CANADA BILATERAL HOG AND PORK TRADE FLOWS

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Abstract

Country of Origin Labelling (COOL) regulation has been applied in the United States meat sector since October 2008. The industry must label beef, lamb and pork (ground meat and muscle cuts) sold through retail outlets according to its country of origin. The labelling requirements create differentiation at the retail level and may impose additional costs on producers, processors and retailers in the U.S. and elsewhere. The purpose of this analysis is to investigate whether there has been structural change in U.S. import demand for Canadian hog/pork products. Given that COOL has been in place for a limited period of time, we implement statistical procedures that are robust to structural change occurring at the end of the sample. We find evidence that COOL has impacted U.S./Canada slaughter hog trade flows. While Canadian feeder hog prices appear to have declined concurrently with the introduction of COOL, statistical hypothesis testing found little evidence of structural change for feeder hog trade flows that could be associated with COOL.

Keywords: Country of origin labelling; Structural change; North American hog/pork sector

1. Introduction

It has barely been a year since the final rule implementing mandatory country of origin labelling (COOL) requirements for retail purchases of red meats in the United States went into effect on March 16, 2009. The meat industry and retail stores are now required to comply with mandatory labelling requirements that beef, lamb and pork (ground meat and muscle cuts) sold through retail outlets are to be labelled according to its country of origin. The legislation has been contentious both within the U.S. livestock and meat industry and with respect to trading partners who depend on U.S. market access. Canada and Mexico have launched a formal dispute settlement procedure at the World Trade Organization (WTO) arguing that COOL violates the trade obligations of the United States. Since January 2008, U.S. bound exports of Canadian live hogs (slaughter hogs and feeder pigs) have steadily declined.

To date, the analysis of COOL has been hypothetical with impacts determined by simulation models or basic economic reasoning. Empirical tests are limited by a shortage of data and confounded by other factors that would affect live hog trade including a relatively higher value for the Canadian dollar, high feed prices, and reduced demand from a weaker economy and recent health concerns (e.g. the association of HIN1 with pork consumption). The objective of this research is to isolate the impact of COOL legislation on trade flows. An econometric model is used to estimate the U.S. import demand of feeder and slaughter hogs. Detecting structural change in the relationship between trade flows and import determinants around the period for which COOL was implemented will be interpreted as a sign that COOL can significantly distort trade flows. The empirical challenge is to detect structural change relying on a very short time period. Statistical procedures developed by Bai and Perron (2003) and Andrews (2003) will be implemented to capture end-of-sample potential structural change induced by COOL.

The remainder of the paper is structured as follows. The next section provides some background to the introduction of COOL requirements in the U.S. The third section provides a literature review of the studies related to COOL. Section four introduces a simple theoretical framework to analyze trade determinants in the context of the North American hog/pork supply chain. Section five presents the empirical model and analyzes the results. The final section offers concluding remarks.

2. Background

The legislative history of COOL is long and convoluted, but understanding it is instructive in terms of detecting when trade flows might initially be affected by the program. The requirements for mandatory COOL stem from the 2002 Farm Bill which directed the USDA to develop regulations to implement mandatory COOL. These regulations were to be promulgated by September 30, 2004. The law subsequently has undergone a number of changes since it was first introduced. First, the law was applied to fish and shellfish in 2004, but the application to the rest of the covered products was delayed until September 30, 2006. The law was then further delayed until September 30, 2008. Finally, the 2008 Farm Bill contained a number of provisions that amended the COOL provisions of the Act and an interim final rule was introduced for September 30, 2008. The final rule, encompassing all covered commodities became effective March 16, 2009.

Another issue that has evolved over time is the labelling requirements of meat sourced from mixed country supply chains. The 2008 Farm Bill included additional provisions for labelling of meat, which have commonly been referred to as categories A, B, C, and D. These categories are described in Table 1.

Table 1: COOL categories

Category A	Meat from animals born, raised and slaughtered in the U.S. Labelled product of the U.S.
Category B	Meat from animals born in Canada and raised and slaughtered in the U.S. Labelled product of U.S. and Canada.
Category C	Meat from hogs born and raised in Canada and slaughtered in the U.S. Labelled product of Canada and the U.S.
Category D	Meat imported into the United States.

Note: Adapted from Meyer (2008).

Since its inception in 2002, the COOL legislation has defined specific requirements for U.S. country of origin (category A) labels. The law states that in order to bear a U.S. origin declaration, the meat must be derived exclusively from animals born, raised, and slaughtered in the United States. The 2008 Farm Bill added the provision that meat derived from animals present in the United States on or before July 15, 2008 (whether domestic or imported) is also eligible to be labelled as U.S. origin. The other clear-cut case in Table 1 includes products for which no stages of production occurred in the U.S. These products are labelled (category D) with an origin as declared to U.S Customs and Border Protection at the time the product is imported.

Over time, concerns have emerged about how to label meat from animals imported from another country and then raised and subsequently slaughtered in the U.S. or animals imported for immediate slaughter. Category B animals include feeder pigs born in Canada and raised and slaughtered in the U.S. Meat derived from animals born, raised, and slaughtered in the U.S. that are commingled during a production day with meat from Canadian born animals, raised and slaughtered in the U.S. and not derived from animals imported for immediate slaughter, may also be designated with label B¹. Furthermore, meat derived from animals that are born abroad and raised and slaughtered in the U.S., that are commingled during a production day with meat from

animals that were imported for immediate slaughter (category C) may be labelled as category B items. In either case, the countries of origin may be listed in any order (Preston and Kim, 2008).

The provisions of COOL add transactions costs to every level of the supply chain (Sparks, 2003; and Van Sickle *et al*, 2003). However, one particular worry has been that hog packing plants and processors will face additional logistical challenges of sorting, inventory and segregation if they choose to procure and sell products that are not entirely of U.S. origin. Ultimately this is a question of whether individual U.S. packing plants will continue to procure Canadian hogs or U.S. raised hogs that were born in Canada. Those packers that do will have to pay the cost of segregating hogs and final products. They may face cutting and boning line stoppages or be required to have separate lines or Canadian shifts. They will have the added cost of managing and recording the segregation process and they will have to label and handle separate products. In short, the major concern is that U.S. slaughter plants may be unwilling to bear the extra costs of maintaining the necessary records and keeping American and Canadian hogs separate.

The flexibility offered in applying different origin sourced hogs to fill out a label B or label C slaughter day will help to mitigate these additional transactions costs and is likely to be an important factor affecting the decision to continue to import hogs (Meyer, 2008). This is especially important for hogs imported for immediate slaughter. If label C was the only option, there would only be limited possibilities to slaughter these hogs. Yet, the degree to which U.S. packers choose to procure Canadian born hogs continues to be an empirical question.

The recent closing of the John Morrell & Co. plant in Sioux City, Iowa has been attributed to a number of factors including an antiquated plant, inefficient and high cost facilities and mandatory COOL.² However, a bigger concern is with Morrell's largest facility, in Sioux

Falls, South Dakota, that sourced roughly 30 percent of Canada's slaughter hog exports.³ A letter to producers dated February 20, 2009 states that the parent company, Smithfield, will only procure hogs that were born and raised in the U.S.⁴ Tyson is the only major packer which has continued to sign purchase agreements with owners of Canadian born pigs. Much of U.S. hog processing occurs in the corn-belt, particularly in Iowa. Tyson's daily Iowa based processing capacity is estimated to be 52,250 hogs (McEwen 2010).

The other factor affecting the potential for Canadian hog exports concerns product coverage and in particular product exclusions from COOL labelling requirements. Two broad categories do not require labelling: *i*) processed products (hams, bacon and sausages or pork in prepared meals are not included); and *ii*) hotel, restaurant, and institutional (HRI) trade. The National Pork Board estimated that 38% of pork meat in 2006 reached consumers through foodservice operations where a label will not be required (Myer, 2008). Furthermore, roughly 65% of the pork carcass is cured, smoked, marinated or spiced to a degree that it is considered a processed product exempt from COOL (Myer, 2008).

Figure 1 presents monthly Canadian exports of live hogs to the U.S. from January 2005 to November 2009. With average annual exports of roughly 6.7 million feeder hogs and just over 2.5 million slaughter hogs, these hogs would require slightly more than half of Tyson's annual slaughter capacity in Iowa. Even the potential to re-direct pork into the HRI trade would result in spatial capacity constraints and a disincentive to export Canadian born hogs, particularly slaughter hogs.

It appears that exports of both feeder (< 50 kg) hogs and slaughter hogs (> 50 kg) started to decline in early 2008 and that this negative trend in exports lasted all the way through 2009. As mentioned above, COOL requirements were officially introduced in September 2008 but not

finally implemented until March 2009. However, for an imported animal to be labelled as product of the U.S., the animal had to be in the U.S. prior to July 15, 2008. So it is difficult to establish a definite date when the effects of COOL actually started. While the decrease in live exports precedes COOL legislative authority by about six months, the July 15 deadline is a possible candidate for an effective start date. Prior to that time, the Food, Conservation, and Energy Act was passed into law on June 18, 2008. Given the lags associated with contractual obligations, it is thus plausible that firms on both sides of the border anticipated that the program would be finally enacted very early (February or March) in 2008 and responded accordingly.

In addition to COOL, many other factors could also impact exports. The end of 2007 marks the official start of the recession in the U.S. This recession became a full-blown worldwide recession towards the end of the 2008 summer with the failure of major financial firms in the U.S. At the same time as the decline in income, the outbreak of a new strain of the flu virus, which was labelled swine flu at the early stages of the epidemic, accelerated the decline in world demand for pork products. This led to lower hog prices in the North American market.⁵ The value of the Canadian dollar is also an important determinant of the competitiveness of Canadian hogs and pork products in the U.S. market. In what follows, we investigate the different determinants of Canadian exports to detect whether isolating the COOL impacts on exports is possible.

Figure 2 presents monthly total Canadian pork exports as well as exports to the U.S. from early 2005 to end of 2009. COOL raises the cost structure for both U.S. and Canadian firms that handle Canadian products, but also may raise the demand for U.S. products. As such, COOL can potentially decrease the demand of Canadian pork meat in the U.S. Total Canadian pork exports have been quite volatile, but overall it is difficult to pick up any negative trend in total pork

exports over the period. Conversely, Canadian pork exports to the U.S. have been relatively stable. There is even a slight, albeit not significant, positive trend beginning in late 2007.

An important determinant of the competitiveness of the Canadian product in the U.S. market is the value of the Canadian dollar with respect to the U.S. dollar. An appreciation of the Canadian currency lowers the price received by Canadian exporting firms for a given price denominated in U.S. dollars. Canadian firms have two (non-exclusive) options. They can either absorb this into a lower profit margin (in \$Can) or try to raise the selling price in \$U.S. Figure 3 illustrates the monthly average value of the \$U.S. per \$Can from January 2005 to December 2009. There has been a steady appreciation of the Canadian currency from early 2005 until the second quarter of 2007. At that point, the Canadian dollar overshot parity with the U.S. dollar and later stabilized around parity until mid-2008. The recession triggered a retreat of the value of the Canadian dollar as investors sought protection from a potential global financial meltdown by buying \$U.S. denominated assets.

Figure 4 presents the monthly average of the unit value (in \$Can) of Canadian pork exports to the U.S. As mentioned before, we would expect this statistic to be negatively correlated with the value of the Canadian dollar. Moreover, COOL could actually lower the price paid by importing firms for Canadian pork products. The pattern in the monthly export unit value indeed seems to be negatively correlated with the exchange rate. The average export unit value declines from early 2005 to early 2008. It increases for most of 2008 and starts declining again towards the end of 2008. Once again, it is impossible from looking at the figure to tell whether COOL has had any impact on Canadian pork meat export prices.

Another explanation for the decline in live hog exports observed in Figure 1 may be the poor economic conditions for hog production in North America. Figure 5 presents the U.S. and

Manitoba Index 100 monthly average of slaughter hog prices from January 2005 to December 2009. North American hog prices were in a precipitous decline in the period prior to the implementation of COOL. Market hog prices recovered through the first half of 2008 and then declined again for most of the rest of 2009. The strengthening of prices was associated with a 2% decline in the U.S. breeding herd inventory over the course of 2008 (Agriculture and Agri-Food Canada). A small rebound in the exports of Canadian feeder hogs coincided with the decline in U.S. hog inventories.

A popular measure of profitability in the hog industry is the hog feed ratio. It reports the number of bushels of corn that are equal in value to 100 pounds of index 100 live hog. The higher (lower) the ratio is, the lower (higher) are feed costs relative to output prices. Figure 6 presents the monthly average hog feed ratio in Ontario from January 2005 to December 2009. The hog feed ratio decreased from early 2005 to early 2008 and stayed relatively constant thereafter throughout 2008 and 2009. The general trend in Figure 6 is indicative of difficult times in the Canadian hog industry.

One method of determining the impact of COOL is to examine the basis between Canadian and U.S. hog prices. In Canada, slaughter hog prices are mostly formula-based and are priced off the U.S. market. Contractual relationships between packers and producers make it difficult for prices to adjust in the short-run as contracts and formulas are revised only a few times per year. Hence, comparing the basis for these prices is not informative. Price comparisons for feeder hogs are more informative because more transactions are carried out using the spot market. Figure 7 illustrates the spread between Manitoba and U.S. monthly average prices for feeder hogs less than 5 kg (i.e. isowean pigs) from January 2005 to December 2009. Early in 2008, the price spread grew to an average of \$15 a pig. This basis closed to parity in April of

2009; returned to a \$14 spread in August and has closed since that time. Figure 8 presents the spread between Manitoba and U.S. monthly average prices of feeder hogs over 5 kg and less than 23 kg. The evidence suggests that a discount for Canadian feeder hogs may have emerged around the time that implementation of COOL became official. Yet the volatility observed afterwards when the price spread shrunk and later reappeared argues for other factors in addition to COOL impacting the size of the basis.

In summary, Figure 1 clearly identifies negative trends in Canadian live hog exports that occur slightly before the introduction of COOL requirements in the U.S. This would suggest that COOL had a potentially negative impact on the Canadian hog industry. Nevertheless, many factors can be conjured up to explain this decline. One can go about detecting COOL impacts on the Canadian hog/pork industry using essentially two approaches. The first approach is to investigate whether prices in each of the market have drifted from one another since the implementation of COOL. Given that COOL can be thought of as increasing transaction costs related to Canadian hogs as well as introducing differentiation between U.S. and Canadian pork meat, one could expect that the resulting lower demand for Canadian hogs translates into lower prices relative to U.S. hogs. There are two major issues with the price approach. First, reliable data must be available. The change in price spreads may be a result of having to ship the hogs further to a plant that will accept them and this effect may not show up in the price comparison. At the very least, weekly data must be employed to measure price dispersion and arbitrage in the Canadian and U.S. markets. Second, modeling hog price arbitrage in the North American market is a difficult endeavour because the market is a collection of regionally integrated markets. For example, the Quebec and Ontario hog industries should be relatively well integrated given their proximity, but there exist significant differences in hog marketing mechanisms such that the

relationship between these two markets might be different than the relationship between each province and the U.S. market.⁶ We chose to investigate the potential impacts of COOL on the Canadian hog industry by looking at trade flows. This strategy involves modeling the U.S. import demand for feeder and slaughter hogs to subsequently determine if the introduction of COOL has had any statistically significant impact on the U.S. demand for Canadian hogs.

3. Literature Review

The literature on mandatory COOL can be divided into four different categories. The first category involves measuring consumers' willingness to pay for meat products of U.S. origin (e.g. Loureiro and Umberger, 2003, Umberger *et al.*, 2003). A second stream of literature involves the mechanism of signalling quality through labelling and the implications for COOL through models of vertical differentiation and explicitly accounting for differences in consumer attitudes to foreign and domestic goods (Zago and Pick, 2004; Joseph, Lavoie and Caswell, 2009; Plastina and Giannakas, 2007). A third stream of literature looks at the market effects and welfare implications of the program. The fourth stream of literature uses *ex-post* analysis to econometrically test for the impact of COOL on actual trade flows.

In terms of the market effects of COOL, Lusk and Anderson (2004) and Brester, Marsh, and Atwood (2004) present equilibrium displacement models to determine the short-run and long-run changes in equilibrium prices and quantities of meat and livestock in the beef, pork, and poultry sectors resulting from the implementation of mandatory COOL. Both studies ignore the impact on Canada and limit their analysis to the U.S. Rude, Iqbal and Brewin (2006) examined the impact of mandatory COOL on the Canadian and U.S. hog and pork sectors and they attempted to trace the added costs of the program as they are passed through the hog/pork market and to determine who gains and who loses. The authors employed a homogenous product model

and they made the rather extreme assumption of a nearly closed border for live animal trade. Other background papers on the potential market impacts of COOL include Hayes and Meyer (2003), Grier and Kohl (2003) and Krissoff *et al.* (2004). Included in this literature are studies that attempt to estimate the increased costs due to COOL requirements (*e.g.*, Sparks Companies Inc., 2003; VanSickle *et al.* 2003).

The problem is that these simulation models all predate the implementation of mandatory COOL and cannot decompose what actually happened. The only sector where there is sufficient evidence for *ex post* empirical testing is in the fish and seafood sector because mandatory COOL was implemented in April 2005. Jones, Somwaru, and Whitaker (2009) examine aggregate fish trade for post-COOL structural changes using use a vector autoregressive (VAR) model to analyze the determinants of both U.S. exports and imports. Even though April 4, 2005 was the actual implementation date the effect of the legislation may occur over an extended period of time because different economic agents may have began preparations to adjust to the program before, or after, the actual implementation date. The authors use a recursive residual approach with a CUSUM test to detect potential structural change in the parameter estimates. They found the residual variances were stable and that there were no significant structural changes in fish trade in the post COOL period.

Wozniak (2010) uses a nonlinear AIDS model of the demand for salmon products (precooked, uncooked fresh, and uncooked frozen) to uncover the impacts of COOL. He uses a series of Chow tests, 24 weeks prior and after implementation, to test for structural change. He finds stable consumer demand despite the introduction of mandatory COOL, implying that COOL has not significantly affected the way consumers purchase salmon products.

4. Conceptual Model

This paper falls in the category of econometric analysis to assess the impact of the introduction of COOL on the export of live Canadian hogs to the United States. We use end-of-sample tests of structural instability to determine if the COOL program has contributed to a fundamental change in the volume of Canadian exports of feeder and slaughter hogs to the U.S. In order to implement this approach several pieces of information are important to set up the model. We use a dataset that covers the January 2000 to November 2009 period. COOL can thus be considered to have a potential impact for a period of 16 to 20 months at the end of the sample. The exact date of the structural break is hard to define, and ultimately this remains an empirical exercise.

The second modelling consideration involves the differentiation of pork meat. Table 1 defines four COOL categories; however from the practical perspective of implementing the proposed model, two types of meat will be purchased in the U.S.: meat from U.S. hogs and meat from hogs of Canadian origin. The nature of the econometric exercise is to explain historic trade flows so the distinction between meat derived from mixed supply chains and meat imported from Canada is not as important as it is in a forward looking simulation which tries to explain future behaviour.

Another consideration is that although transactions costs brought on by COOL will affect trade flows, they are not necessary for a trade distortion to occur. As long as the two types of meat are differentiated from the consumers' perspective, the level of imports will be different with and without COOL. However, if differentiation is not important, exports under the two scenarios will not be significantly different. If product differentiation and transactions costs are important, it should be possible to detect structural change in the regression coefficients around the time that COOL was introduced.

The approach used to test for the structural change associated with COOL is to estimate reduced form import demand equations for feeder and slaughter hogs that are a function of the variables that will shift the domestic supply and demand functions. Let the subscript F , H , and M denote a feeder hog, a slaughter hog and pork meat, respectively. Countries are indexed by the superscript $j = US, C$. Let p_F^j and w_F^j denote the price of feeder hogs and input costs of feeder hog producers in country j , respectively. Assume the feeder hog supply in country j is: $S_F^j(p_F^j; w_F^j)$. On the hog production side, we assume that hog producers use a fixed-proportion technology to bring hogs to market weight. Furthermore, assume that the conversion ratio between feeder and slaughter hogs is equal to one. This assumption does not result in a loss of generality because the conversion factor will be picked-up by the coefficients of the model at the empirical stage. Under these assumptions, the supply of slaughter hogs will be function of the price margin between slaughter and feeder hogs as well as a function of cost shifters specific to the sector; *i.e.*, the slaughter hog supply in country j is: $S_H^j(p_H^j - p_F^j; w_H^j)$; where w_H^j and p_H^j represent a cost shifter for hog producers of country j and the hog price in country j , respectively.

Using the same assumption of a fixed proportion technology in the processing sector, the pork meat supply curve in country j is: $S_M^j(p_M^j - p_H^j; w_M^j)$, where w_M^j and p_M^j represent a cost shifter for processors and the pork meat price in country j , respectively. Finally, the pork meat demand in country j is represented by: $D_M^j(p_M^j, y^j)$; where y^j is a demand shifter (possibly income) in country j .

As in Moschini and Meilke (1992), we restrict our attention to the North American hog/pork sector and assume away third-country trade flows. Given the assumption of homogenous products, and after making substitutions for vertical supply chain relationships (*i.e.*

that the supply of slaughter hogs equals the demand for feeder hogs and that the supply of meat equals the demand for slaughter hogs), the market clearing conditions in the feeder hog, slaughter hog and pork meat markets are:

$$(1) \quad S_M^C(p_M^C - p_H^C; w_M^C) + S_M^{US}(p_M^{US} - p_H^{US}; w_M^{US}) = D_M^C(p_M^C, y^C) + D_M^{US}(p_M^{US}, y^{US})$$

$$(2) \quad S_F^C(p_F^C; w_F^C) + S_F^{US}(p_F^{US}; w_F^{US}) = S_H^C(p_H^C - p_F^C; w_H^C) + S_H^{US}(p_H^{US} - p_F^{US}; w_H^{US})$$

$$(3) \quad S_H^C(p_H^C - p_F^C; w_H^C) + S_H^{US}(p_H^{US} - p_F^{US}; w_H^{US}) = S_M^C(p_M^C - p_H^C; w_M^C) + S_M^{US}(p_M^{US} - p_H^{US}; w_M^{US})$$

Under the assumptions of liberalized trade, no transaction costs between the U.S. and Canadian markets, and parity between the Canadian and U.S. dollars, then price equality holds across the regions: $p_F^C = p_F^{US} = p_F$, $p_H^C = p_H^{US} = p_H$ and $p_M^C = p_M^{US} = p_M$. The system of three market clearing conditions can be used to solve for the three prices. U.S. imports of Canadian feeder hogs, slaughter hogs and pork meat are:

$$(4) \quad ED_F^{US} \equiv S_H^{US}(p_H^{US} - p_F^{US}; w_H^{US}) - S_F^{US}(p_F^{US}; w_F^{US})$$

$$(5) \quad ED_H^{US} \equiv S_M^{US}(p_M^{US} - p_H^{US}; w_M^{US}) - S_H^{US}(p_H^{US} - p_F^{US}; w_H^{US})$$

$$(6) \quad E_M^{US} \equiv D_M^{US}(p_M^{US}, y^{US}) - S_M^{US}(p_M^{US} - p_H^{US}; w_M^{US})$$

Now consider the potential implications of country of origin labelling. Assume that there are two different products sold at the U.S. retail level: a U.S. product and a mixed supply chain product. We will assume that the origin of the product is determined by the origin of the slaughter hog. We will abstract away from mixed supply chains of meat where the animal is born in Canada, fed in the U.S. and slaughtered in the U.S. and merely differentiate between animals that were born and not born in the U.S. Given imperfect substitution between mixed supply chain and U.S. pork, the demand schedules for pork meat in the U.S. market can be rewritten as:

$D_M^{US,C} (p_M^C; p_M^{US}, y^{US})$ and $D_M^{US,US} (p_M^{US}; p_M^C, y^{US})$ where the superscript US,j denotes consumption of a product of origin j in the U.S. market. On the Canadian side, there are no distinctions between U.S. and Canadian products at the retail level. U.S. processors can use Canadian hogs or U.S. hogs to produce meat. The origin of the hog used in the production of meat will determine which supply chain a U.S. processor belongs to. The U.S. processor selling Canadian meat have supply function: $S_M^{US,C} (p_M^C - \tau - p_H^C; w_M^{US})$, while others selling U.S. pork meat have supply: $S_M^{US,US} (p_M^{US} - p_H^{US}; w_M^{US})$.⁷

We can use the vertical relationships in the supply chain to simplify the market equilibrium conditions in the North American hog/pork sector. The supply of Canadian and U.S. processed Canadian meat is identical to the demand for Canadian hogs. The supply of U.S. meat is identical to the demand for U.S. hogs and the supply of Canadian and U.S. slaughter hogs are substituted for the demands for feeder hogs. The market clearing conditions are thus:

$$(7) \quad S_M^C (p_M^C - \tau - p_H^C; w_M^C) + S_M^{US,C} (p_M^C - \tau - p_H^C; w_M^{US}) = D_M^C (p_M^C, y^C) + D_M^{US,C} (p_M^C; p_M^{US}, y^{US})$$

$$(8) \quad S_M^{US,US} (p_M^{US} - p_H^{US}; w_M^{US}) = D_M^{US,US} (p_M^{US}; p_M^C - \tau, y^{US})$$

$$(9) \quad S_H^C (p_H^C - p_F; w_H^C) = S_M^C (p_M^C - \tau - p_H^C; w_M^C) + S_M^{US,C} (p_M^C - \tau - p_H^C; w_M^{US})$$

$$(10) \quad S_H^{US} (p_H^{US} - p_F; w_H^{US}) = S_M^{US,US} (p_M^{US} - p_H^{US}; w_M^{US})$$

$$(11) \quad S_F^C (p_F; w_F^C) + S_F^{US} (p_F; w_F^{US}) = S_H^C (p_H^C - p_F; w_H^C) + S_H^{US} (p_H^{US} - p_F; w_H^{US})$$

This system of five equations (7)-(11) can be solved for the five endogenous variables $\{p_M^C, p_H^C, p_M^{US}, p_H^{US}, p_F\}$. Substituting the equilibrium prices in the Canadian and U.S. demand and supply schedules of the hog/pork sector, we can define the U.S. import demand for feeder hogs, slaughter hogs and pork meat as functions of exogenous variables:

$$(12) \quad I_F^{US} \equiv \phi_F \left(w_F^{US}, w_F^C, w_H^{US}, w_H^C, w_M^{US}, w_M^C, y^{US}, y^C \right)$$

$$(13) \quad I_H^{US} \equiv \phi_H \left(w_F^{US}, w_F^C, w_H^{US}, w_H^C, w_M^{US}, w_M^C, y^{US}, y^C \right)$$

$$(14) \quad I_M^{US} \equiv \phi_M \left(w_F^{US}, w_F^C, w_H^{US}, w_H^C, w_M^{US}, w_M^C, y^{US}, y^C \right)$$

where I_j^{US} represents U.S. imports of commodity j ($j = F, H, M$). The estimation procedure described in the next section involves estimating the reduced form equations for U.S. imports defined in eq. (12), (13) and (14). The supply and demand shifters w_j^i ($j = H, F; i = C, US$) used in the empirical model are introduced in the next section.

5. Data and the Empirical Model

As mentioned in the introduction, the empirical challenge is to implement a robust procedure to detect structural change in an equation when the number of observations in the period of potential change is small. The Chow (1960) test is widely used to investigate parameter stability in linear regressions. The disadvantage of this procedure is that it relies on strong distributional assumptions (normal errors and exogenous regressors). Andrews (2003) proposes a variant of the Chow test (labelled the S test) that is valid under non-normal, heteroskedastic and/or autocorrelated errors and with potentially endogenous regressors. To illustrate this approach, consider the following two-regime linear regression model with Y_t denoting the dependent variable and \mathbf{X}'_t a vector of that includes d regressors:

$$(15) \quad Y_t = \begin{cases} \mathbf{X}_t \boldsymbol{\beta}_1 + u_t & t = 1, \dots, n \\ \mathbf{X}_t \boldsymbol{\beta}_2 + u_t & t = n+1, \dots, n+m \end{cases}$$

where n denotes the number of observations in the first regime, m denotes the number of observations after the changepoint and $T = n + m$. Structural change occurs at changepoint n in

the regression framework above. The null hypothesis of no structural change is $\beta_1 = \beta_2$ against the alternative that the two vectors are not equal or that the distribution of the error terms is different in each regime.

The Chow test is based on the difference between the unrestricted (two individual models) and restricted (single linear model) residual sum of squares. Under strong distributional assumptions, the asymptotic distribution of the test converges to a F distribution under the null that the coefficients in β_i are not different. The computation of Andrews' S test is done much the same way as the Chow test, except that the approach accounts for the fact that the number of observations in the second regime may be lower than the number of regressors. The critical values of the S test are based on sub-sampling procedures over the first $n - m + 1$ observations.

In the empirical analysis below, we will set up three log-linear equations⁸ that explain Canadian exports of live hogs (feeder and slaughter hogs) and pork meat to the U.S. as a function of different supply and demand shifters for the sector. Monthly data from January 2000 to November 2009 is used for a total of 199 observations. Hog/pork exports were obtained from the red meat market division of Agriculture and Agri-Food Canada. The shifters of the pork meat supply schedule is the monthly average hourly earnings in the U.S. and Canadian meat processing sector obtained from the U.S. Bureau of Labor Statistics and Statistics Canada, respectively. Given the fixed proportion technology in pork production, these shifters also identify the hog demand schedules in Canada and the U.S.

The supply schedule shifters for hog production in Canada and the U.S. are the monthly average price of barley and corn, respectively. The two price series were obtained from the Market Analysis Group of Agriculture and Agri-Food Canada. Once again, the assumption of a fixed proportion technology for hog production allows identifying both the demand for feeder

hogs and the supply of slaughter hogs. The shifters of the pork meat demand schedule in Canada and the U.S. are, respectively, the seasonally adjusted labour income in Canada in 2005 constant dollars obtained from Statistics Canada and seasonally adjusted personal income in the U.S. in 2005 constant dollars obtained from the U.S. Department of Commerce. Other demand shifters such as price indexes for substitute goods were considered. However, only income was used as a shifter to have a parsimonious specification for the export equations. It is difficult to obtain a relevant supply shifter for feeder hog production because most of the variable costs are difficult to track down (such as veterinary service expenditures, etc.). Feed prices are expected to have some impact on the supply schedule of both feeder and slaughter hogs. We use a linear trend as a cost shifter of feeder hog production to capture potential growth in the industry. Finally, we use the value of the Canadian dollar relative to the U.S. dollar as reported by Statistics Canada to capture exogenous factors that impact the demand for Canadian hogs.⁹

The only drawback of the S test is that n must be specified a priori. We know that COOL was implemented in September 2008, but it is highly likely that firms anticipated the impacts of the new regulations and adjusted their behaviour accordingly before the September 2008 date. Indeed, Figure 1 illustrates that exports of feeder and slaughter hogs started to decline in early 2008, raising the possibility that COOL impacts preceded September 2008. Ultimately, it remains a question that can only be solved empirically. In order to obtain a better idea of the potential break point dates, we first implemented the structural change procedure of Bai and Perron (2003, hereafter BP). They consider multiple structural changes in the multivariate regression:¹⁰

$$(15) \quad Y_t = \mathbf{X}_t \boldsymbol{\beta}_j + u_t; \quad t = T_{j-1} + 1, \dots, T_j$$

for $j=1,\dots,q+1$, where q is the number of breakpoints. The indices (T_1,\dots,T_q) are the breakpoints which are estimated jointly with the coefficients of each regime. The model in (15) can be estimated with a sequential procedure that relies on least squares to estimate the coefficients in β_j given a certain partition. The optimal partition is selected in a second stage as the one that minimizes the residuals sum of squares.

BP also proposed a different procedure to estimate (15) because the sequential estimator rapidly becomes cumbersome when the number of regimes exceeds two. They argue for an algorithm based on the principle of dynamic programming that considerably reduces the number of segments for which the model sum of squares needs to be computed. BP's procedure offers many benefits. We can construct confidence intervals around the break dates and we can formally test the null hypothesis of no structural change against different alternatives. They suggest first testing the null of no breaks against the alternative of an unknown number of breaks (given an arbitrarily large upper bound). If at least one break is detected, they suggest proceeding with the tests of l breaks against the alternative of $l+1$ breaks using a variant of the supF test developed by Andrews (1993).¹¹

BP supplied the appropriate asymptotic theory for the tests, but emphasize that the size and power of these tests are conditional on the trimming factor (i.e. the minimum number of observations in each regime). For example, the overall testing procedures can be quite robust to the presence of autocorrelation in the residuals as well as different variances in each regime, but they require a trimming factor of at least 0.15. Given we have 119 observations in the sample, a trimming factor of 0.15 would require 18 observations in each regime. In that case, the last regime could start at the latest in June 2008. In what follows, we decided to specify a trimming factor of 0.10 to make sure it is possible to identify potential COOL-induced structural change.

While this may not constitute a robust investigation of structural change, it has the advantage of endogenizing the timing of a potential break. It is also comforting to know that the procedure of Andrews (2003) will give us a more robust method to detect structural change if autocorrelation is present.

Following BP, we first computed the test statistic of the null hypothesis of no structural change against the alternative of more than a single regime. Let M be the upper bound on the number of potential breakpoints. This test uses a combination of the SupF test statistic computed for $m = 1, \dots, M$ breakpoints. The test statistics are 179.88, 90.93 and 262.96 for the feeder hog, slaughter hog and pork meat export equations, respectively. The critical value of the test at the 5 percent significance level is 26.48 and thus the tests overwhelmingly reject the null hypothesis that there is no structural change in the relationship between hog/pork exports and exogenous covariates.

The supF test statistics of the null hypothesis of a single breakpoint against the alternative of two breakpoints are 29.79, 59.80, and 32.28 for the feeder hog, slaughter hog and pork meat export equations, respectively. The critical value of the test at the 5 percent significance level is 26.20 and thus the tests suggest that there are at least two breakpoints (three regimes) in the sample. The supF test statistics of the null hypothesis of two breakpoints against the alternative of three breakpoints are 18.59, 33.87, and 27.31 for the feeder hog, slaughter hog and pork meat export equations, respectively. The critical value at the 5 percent significance level is 28.23; it thus suggests that the feeder hog and pork meat export equations have two breakpoints while the slaughter hog export equation could have three breakpoints (four different regimes). Confidence intervals around the dates of the breakpoints are provided in Table 2. The confidence intervals

are generally narrow, with the exception of the second regime of the slaughter hog export equation.

Table 2: Results of the BP procedure

Series	95% confidence interval around breakpoints
Feeder hog exports	
First breakpoint	[Aug-02; Sep-02]
Second breakpoint	[Jan-08 ; April-08]
Slaughter hog exports	
First breakpoint	[May-03 ; Sep-03]
Second breakpoint	[Aug-07 ; Oct-07]
Third breakpoint	[Aug-08 ; Oct-08]
Pork meat exports	
First breakpoint	[Apr-01 ; Jun -01]
Second breakpoint	[Apr-02 ; Jun-02]

Before getting to Table 2's breakpoints potentially linked to COOL, it is relevant to note that structural change is also detected early in the sample. There have been lingering trade disputes between Canada and the U.S. with regards to live hog trade. These disputes could trigger adjustments in the U.S. import demand. Countervailing duties on Canadian hog exports were lifted in early 2000 after nearly fifteen years of trade barriers imposed in retaliation for subsidies deemed unfair by the U.S. Department of Commerce. Structural change in pork exports is detected about 15 months after countervailing duties were removed, but structural change in live hog exports appear too late in the sample to be consistent with the termination of the trade dispute. A petition requesting anti-dumping and countervailing duties was filed against Canadian exporters of live hogs in March 2004, but structural change predates this period. Structural change in live hog exports coincides with the discovery of a BSE case in Canada and the shutdown of the U.S. border to imports of live bovine animals from Canada. Despite linkages

between the beef and pork sectors on the demand side, it seems farfetched to link the May-03 / Sep-2003 breakpoint to the BSE incident.

The results in Table 2 clearly suggest that COOL may have an impact on trade flows of slaughter and feeder hogs. The procedure does not identify a significant impact for pork exports. This is significant because we expect the three markets to be strongly linked. Yet, evidence in Table 2 suggests that any bottleneck created by COOL in the feeder and slaughter hog markets has not triggered adjustments in Canadian pork exports to the U.S.

The next step involves implementing Andrews' S test for structural change. Table 3 reports the probability of obtaining a test statistic at least as large as the one observed assuming the null hypothesis of no structural change is true. A low p -value leads to rejecting the null hypothesis of no structural beginning at the date listed in the right hand-side column of Table 3. Given the uncertainty related to the beginning period of the adjustments leading to the implementation of COOL, we decided to compute the S test for n going from September 2007 to October 2008. The only instances in which the p -value of the S test falls below 0.10 is for the slaughter hog export equation and structural change beginning in March or April 2008. The null hypothesis of no structural change (or equivalently of COOL having no impacts on the North American hog/pork sector) could not be rejected for feeder hog exports and pork meat exports. The breakpoint identified for the slaughter hog export equation occurs slightly before the third regime identified by the BP procedure as reported in Table 2.

Table 3: *P*-value of the null hypothesis of a break point

Break point	Feeder hog exports	Slaughter hog exports	Pork meat exports
Sep-07	0.735	0.368	0.998
Oct-07	0.643	0.314	0.971
Nov-07	0.542	0.306	0.972
Dec-07	0.257	0.257	0.959
Jan-08	0.211	0.145	0.921
Feb-08	0.244	0.128	0.910
Mar-08	0.438	0.063	0.900
Apr-08	0.549	0.061	0.890
May-08	0.310	0.131	0.905
Jun-08	0.279	0.198	0.895
Jul-08	0.330	0.477	0.852
Aug-08	0.433	0.178	0.844
Sep-08	0.315	0.217	0.902
Oct-08	0.489	0.287	0.893

One issue to consider is that the presence of structural change at the beginning of the sample may lower the ability of the *S* test to detect structural change at the end of the sample given the procedure only detects the presence of a second regime in the regression equation. Table 2 clearly suggests that all three equations exhibit structural change in 2002 or 2003. We repeated the *S* test algorithm above by deleting the first four years of data. We thus have 71 observations in the sample that goes from January 2004 to November 2009. The results are not reported here but are very similar to the results reported in Table 3. We could not reject the null hypothesis of no structural change for the slaughter hog and pork meat export equations and marginally found statistically significant results around the March/ April 2008 period for the feeder hog export equation.

The tests of structural change do not provide unequivocal evidence that COOL affected trade flows, especially for feeder hogs. Figure 1 clearly shows that the absolute volume of live hog exports did decline significantly in early 2008, so an alternative explanation of this decline

should be considered. The empirical model however does provide information about how exogenous factors - the recession, appreciation of the Canadian dollar and feed prices - affect the exports of live hogs. The model allows us to disentangle the influence of COOL relative to these other factors. A simulation approach is used to ask what would have happened to trade flows associated with an earlier trade regime – pre-2008 – if the exogenous factors for the 2008-2009 period had prevailed during this earlier regime. The simulated trade flows are compared with actual trade flows for the 2008-2009 period. The difference in trade flows gives an indication of the importance of the exogenous factors in the post-COOL period.

Figure 9 plots both actual monthly exports of Canadian feeder hogs from January 2008 to November 2009 and predicted feeder hog exports conditional on the exogenous variables for that time period. The latter series represent trade flows computed using the estimates of the bilateral trade flow equation in the second regime. The general trend in both series is negative, and the model and exogenous factors explain actual trade flows rather well. This suggests that even if we are to assume that some structural change occurred in early 2008, the dynamics of the feeder market prior to that period would still yield a decline in overall exports of Canadian feeder hogs.

Figure 10 presents comparable simulations for exports of slaughter hogs. In this case, we used April 2008 as the beginning period of the new regime which is potentially induced by COOL. The simulated model, using the 2008-2009 exogenous values, does not explain actual trade flows very well. The predicted trade flows are higher, and more variable, than actual exports in the post April 2008 period. This higher volume of predicted exports is consistent with a structural shift that was uncovered with the Andrews procedure between February and March 2008. This suggests that the difficult economic environment in the North American hog/pork

cannot in itself explain the decline of slaughter hog exports from Canada and COOL does appear to be responsible for the trade impact.

6. Concluding Remarks

The North American hog/pork sector has gone through significant economic turmoil in the last three years. The industry had to fight through a worldwide economic recession and a new strain of the flu virus that lowered the global demand for pork products. It had to compete in an environment of higher feed grain prices and declining hog prices. The Canadian hog/pork industry was also challenged by the increase in the value of the Canadian dollar which lowered the overall competitiveness of the industry in the U.S. and other foreign markets. Finally, COOL legislation in the U.S. has potentially further impeded the competitiveness of the Canadian industry by placing additional transactions costs on those firms handling Canadian hogs and pork meat. The purpose of this paper is to investigate whether COOL legislation had significant impacts on Canada/U.S. bilateral trade flows of feeder hogs, slaughter hogs and pork meat.

The most significant challenge in the empirical investigation is to sort out the impact of COOL from the other factors that can affect trade flows given the relatively short period of time for which the policy has been in effect. While COOL has a complicated history, it was only permanently enacted in March 2009. The data analysed are monthly exports from January 2000 to November 2009. The data clearly show that Canadian exports of feeder and slaughter hogs started to decline in early 2008. At that time, the price spread between Canadian and weanling hogs also increased to one-third of the value of the pig. Given that it is easier to demonstrate trade impacts than to explain specific price impacts we sought to look for the impact of COOL through structural changes in U.S. import demand schedules. The empirical strategy consisted of specifying reduced-form equations for imports of feeder hogs, slaughter hogs and pork meat and

conducting tests of structural change on the coefficients of the resulting import demand schedules. The import demand functions account for changes in exogenous variables that impact trade flows such as the Can/U.S. exchange rate, relative feed grain prices, etc.

We implemented Bai and Perron (2003, hereafter BP) and Andrews (2003)'s procedures. The former has the advantage of endogenizing the potential break dates in the regression equations and provides confidence intervals around the break dates. The performance of the BP tests however critically depend on a trimming factor which may not be set low enough to detect COOL-induced structural change that happens at the end of the sample. Andrews' testing procedure has the advantage of being robust to various assumptions about the behaviour of the regression residuals and has especially good properties when the structural change happens towards the end of the sample. The downside is that the potential break date must be specified *a priori*.

It is difficult to pinpoint exactly when COOL had an impact on live hog trade flows. It is certainly possible that producers and packers anticipated the effects of COOL and responded to expected additional costs in the supply chain before the official implementation date of March 2009. Ultimately, this remains an empirical question which is addressed through our 2-stage testing strategy. The BP procedure reveals break points in the reduced-form equations for feeder and slaughter hogs around March 2008 and September 2008, respectively. The confidence interval around these dates is rather narrow. Yet, the BP procedure is bound to have low power when structural change occurs towards the end of the sample. Andrews (2003)'s procedure addresses this shortcoming. The Andrews test reveals rather weak evidence of potential structural change. It fails to reject the null hypothesis of no structural change in the case of feeder

hog exports and pork meat but does reject the null hypothesis of no structural change (p -value slightly less than 0.10) when a break occurs in March 2008 for the slaughter hog export equation.

The challenges of detecting COOL-induced impacts are significant. Researchers only have limited data available to test the implications of COOL and there are many factors that influence price and trade flows in the North American hog/pork industry. Simulations reveal that much of the decline in feeder hog exports can be explained by other exogenous factors that affect the competitiveness of Canadian exports. Conversely, the negative trend in slaughter hog exports to the U.S. is mostly a function of the structural change induced by COOL. The ability to parse out these affects and truly measure the impact of COOL will require more time and more data.

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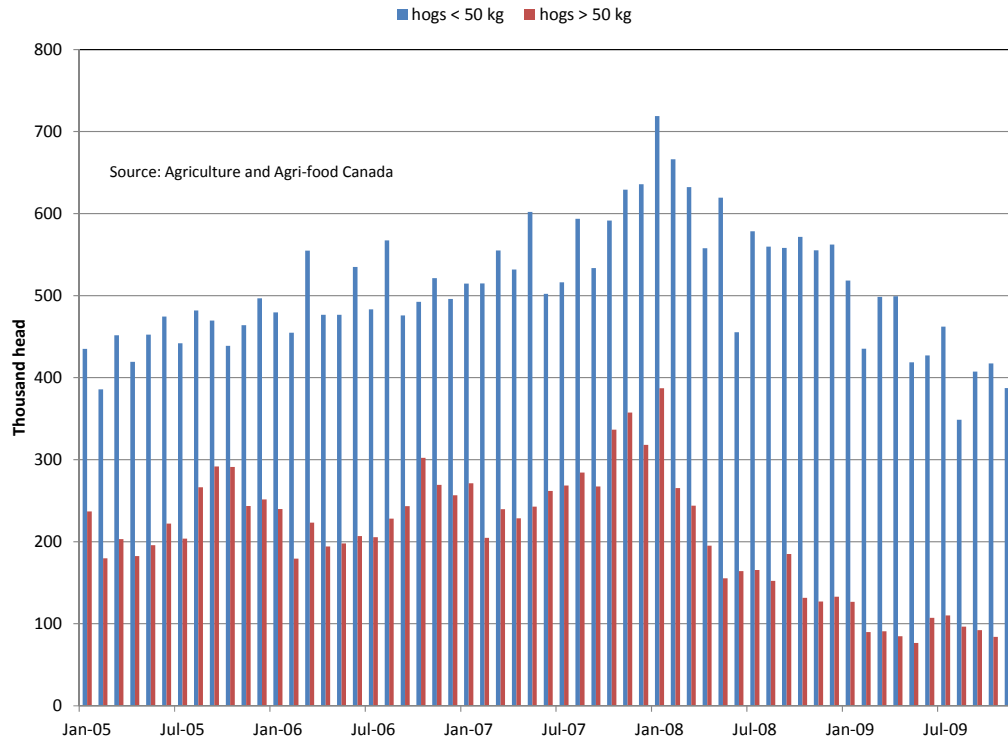


Figure 1: Monthly Canadian live hog exports from January 2005 to November 2009

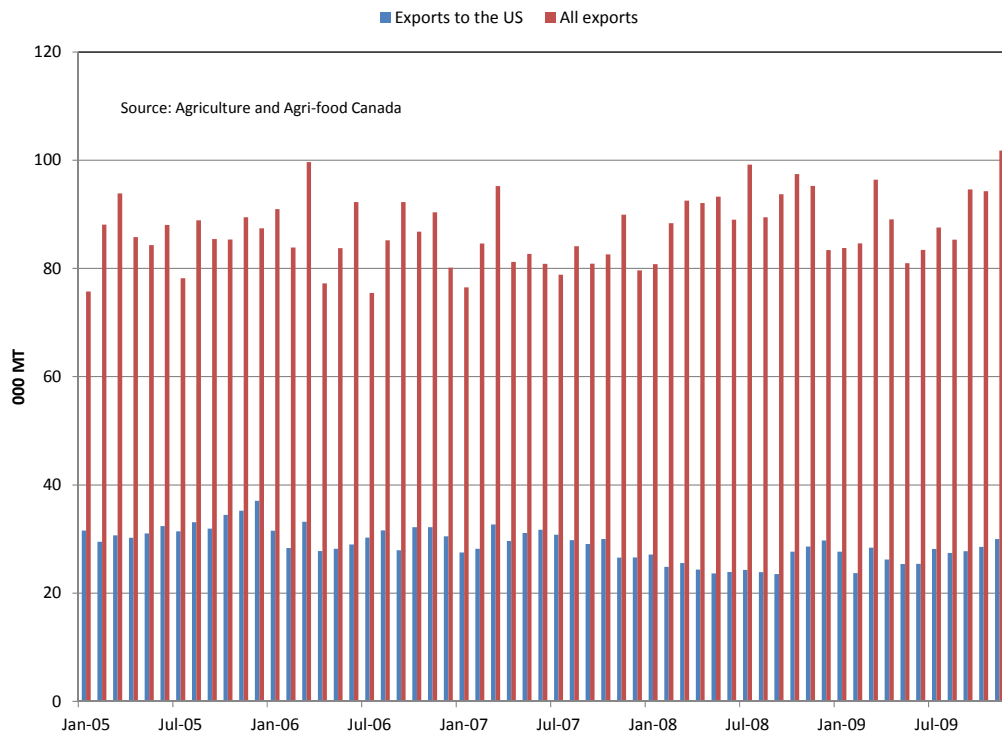


Figure 2: Monthly Canadian pork exports from January 2005 to November 2009

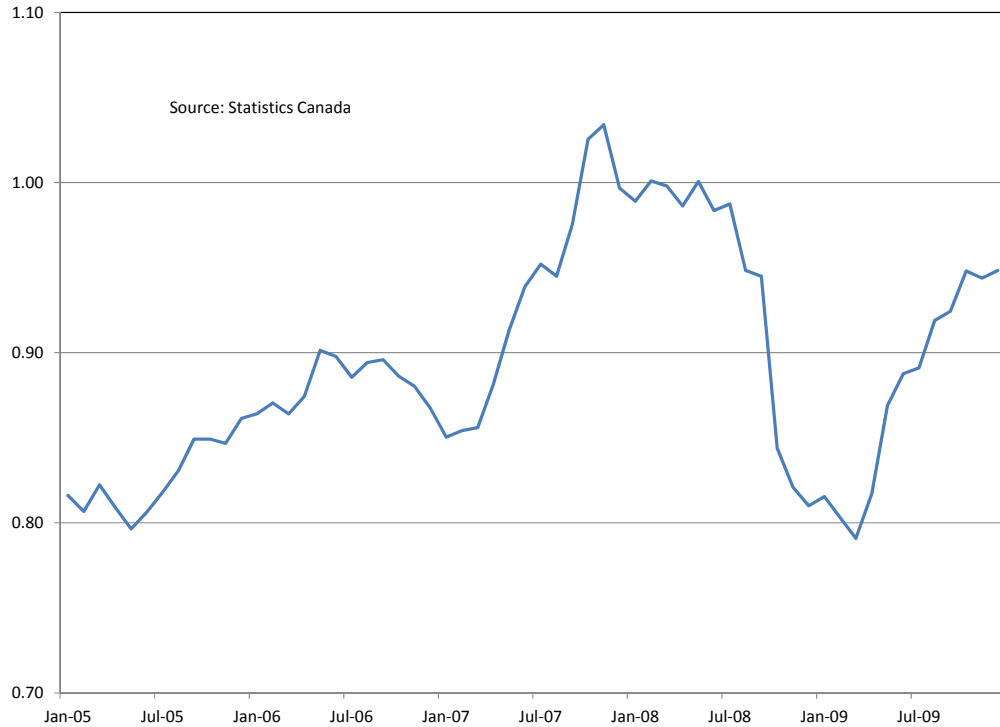


Figure 3: Weekly value of the U.S. dollar per Canadian dollar from January 2005 to December 2009

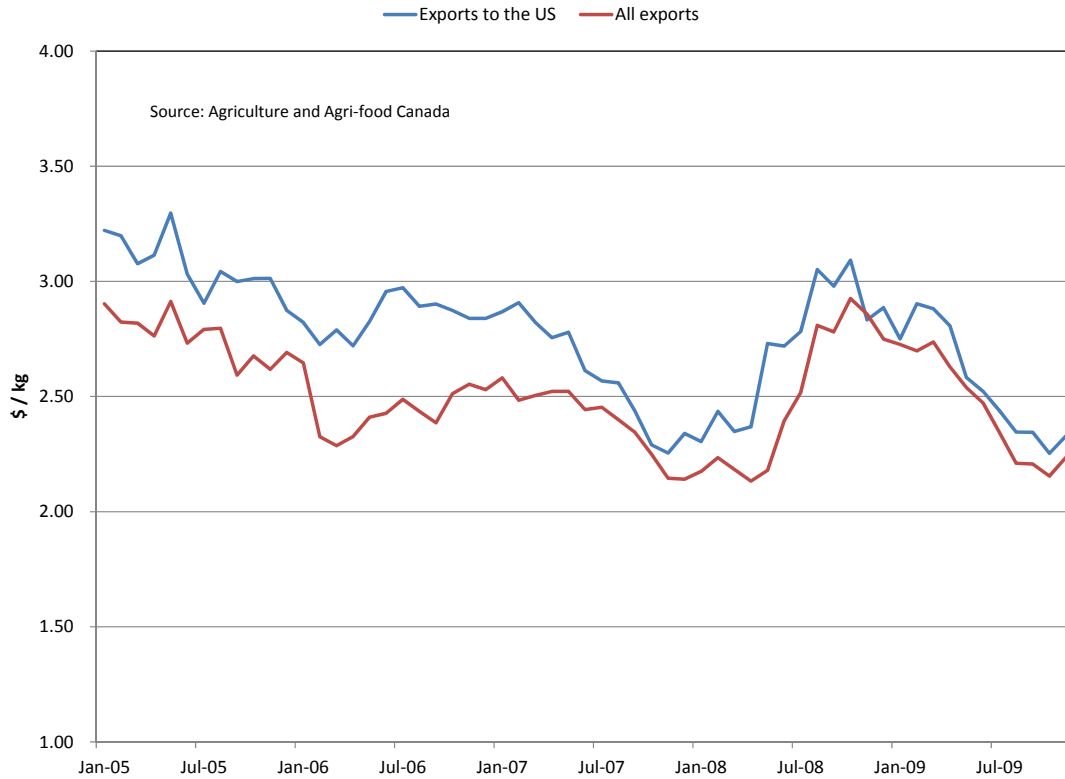


Figure 4: Monthly Canadian pork export unit values from January 2005 to November 2009

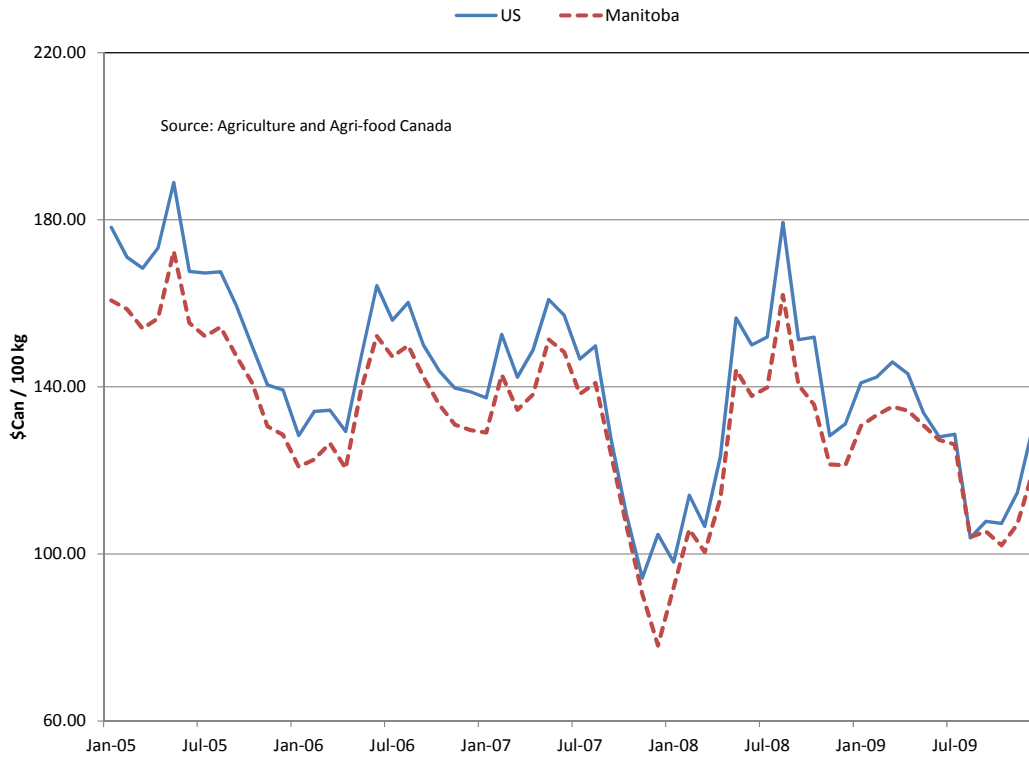


Figure 5: Monthly average of slaughter hog prices in the U.S. and Manitoba from January 2005 to December 2009.

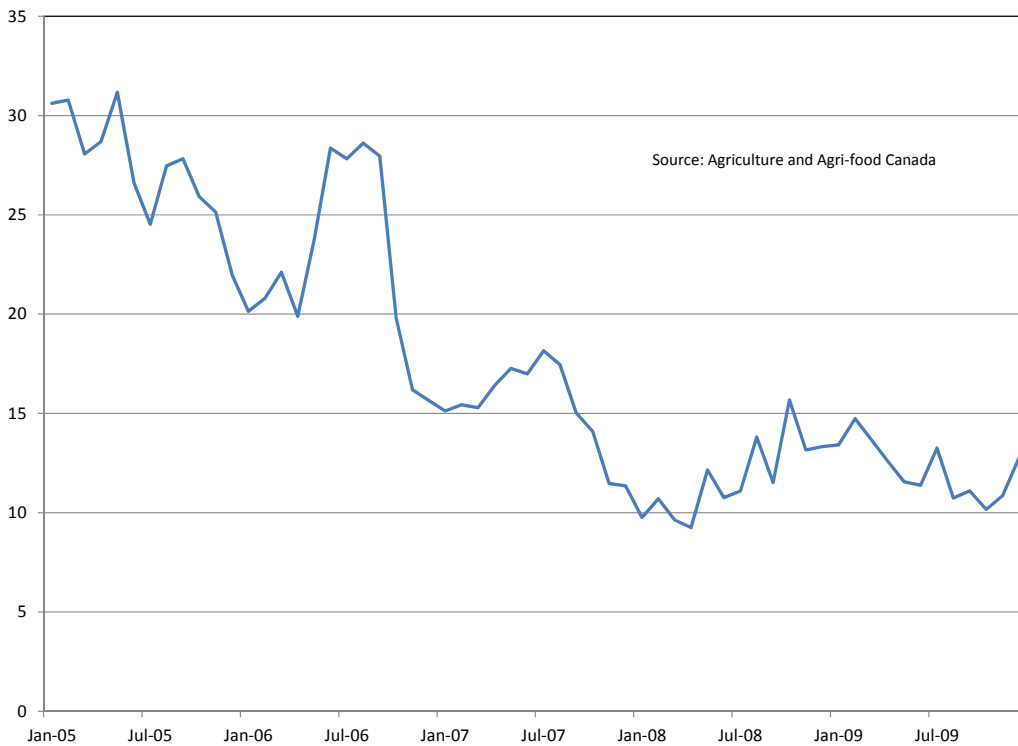


Figure 6: Monthly average of the hog/feed ratio in Ontario from January 2005 to December 2009

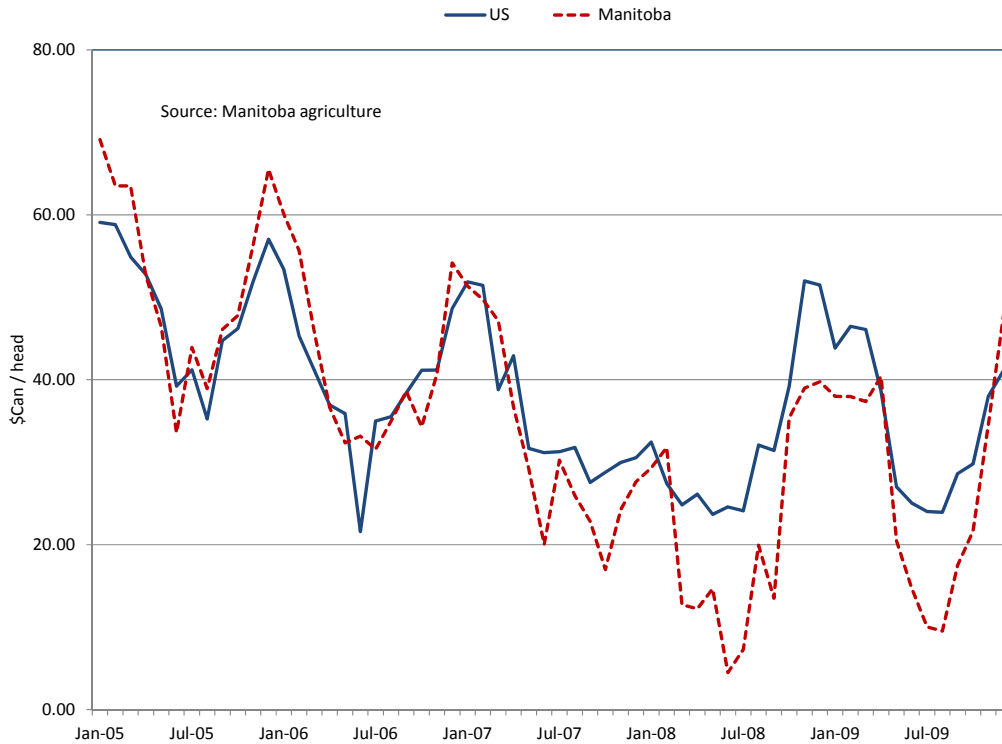


Figure 7: Monthly average of isowean (< 5 kg) hog prices in the U.S. and Manitoba from January 2005 to December 2009

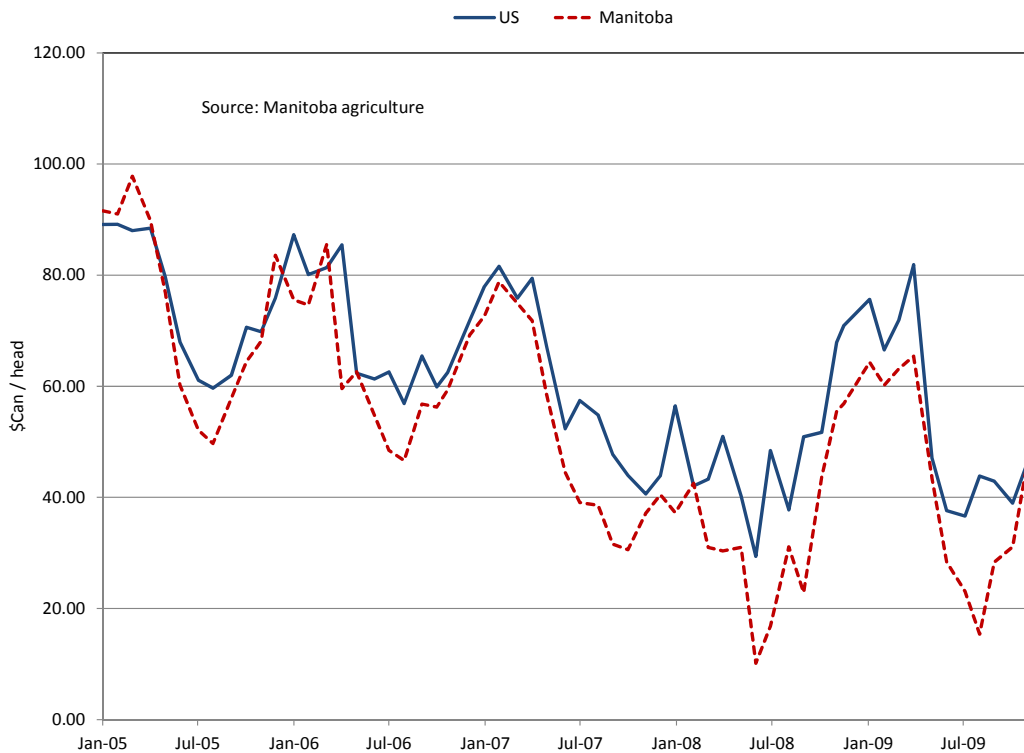


Figure 8: Monthly average of feeder hog (between 5 kg and 23 kg) prices in the U.S. and Manitoba from January 2005 to December 2009

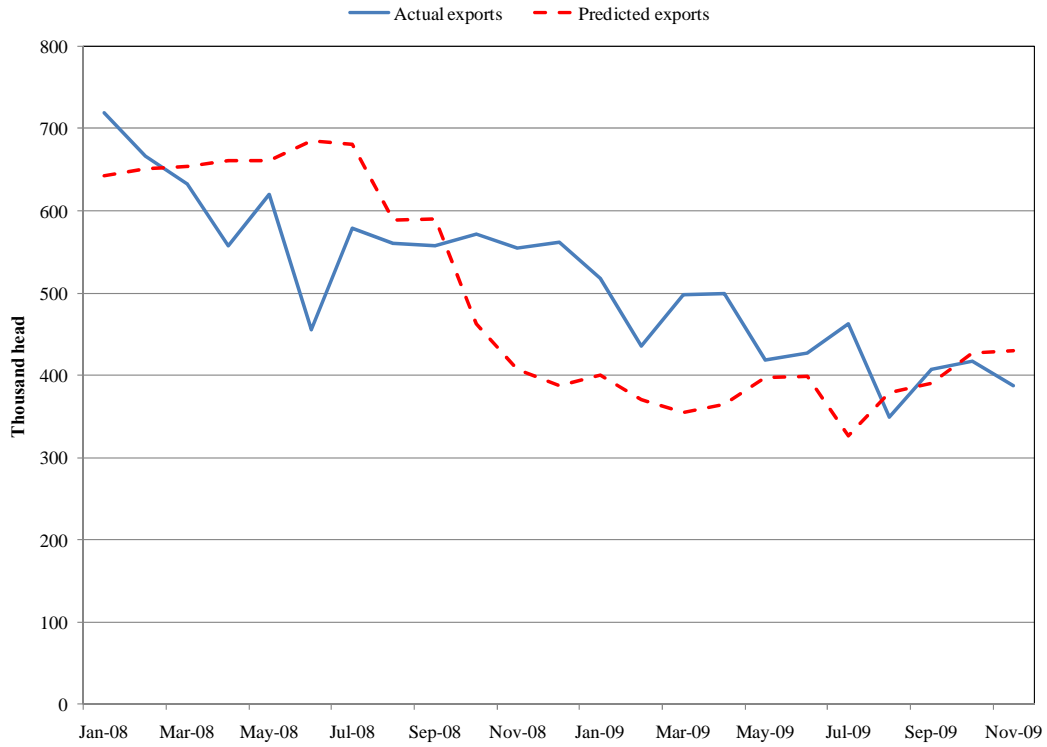


Figure 9: Actual and predicted feeder hog trade flows from January 2008 to November 2009

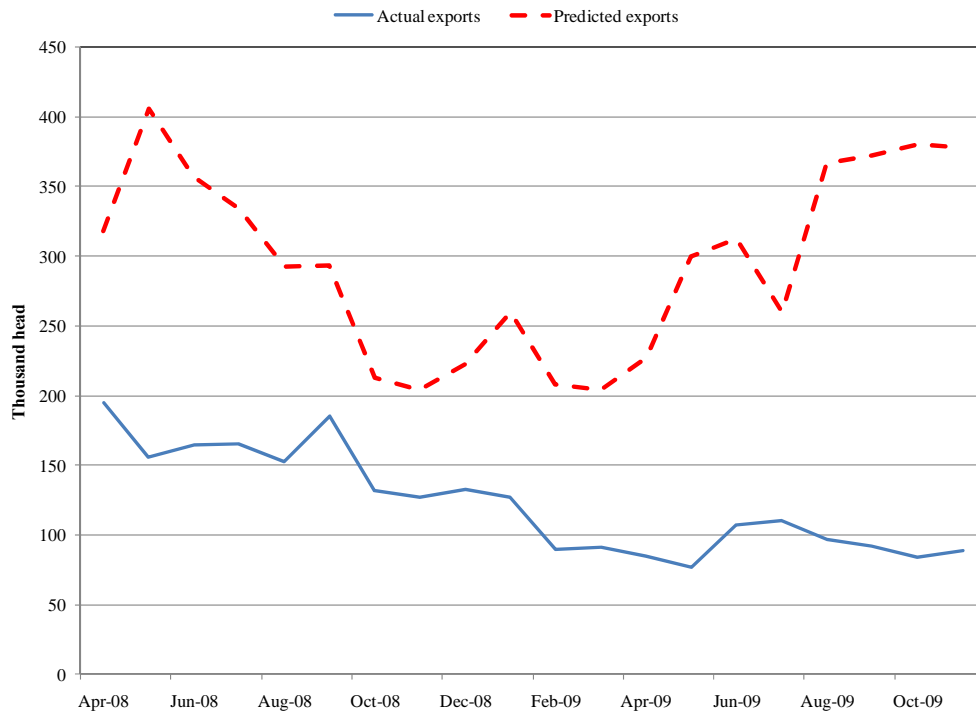


Figure 10: Actual and predicted slaughter hog trade flows from January 2008 to November 2009

Endnotes

¹ A February 20, 2009 letter from US Agriculture Secretary Vilsack to industry representatives advocates voluntary labelling that includes information about what production step occurred in each country. The letter indicates that he may consider modifications to the legislation if industry participants do not include this voluntary information. This action may preclude US packers from labelling US origin meat as label B and ultimately increase the transactions costs for mixed supply chain products.

² See www.thepigsite.com/swinenews/22994/cme-john-morrell-plant-closure-hog-prices. Accessed March 24, 2010.

³ This is based on an estimate (Statistics Canada 2000) that 61% of Manitoba's slaughter hogs are shipped to South Dakota where the Morrell plant is the only significant hog packer. In 2007, 1.3 million of Canada's 2.8 live slaughter hog exports originated in Manitoba. This translates to 800 thousand hogs or 30% of Canada's slaughter hog exports.

⁴ See www.meatcool.info/Morrell%20Letter%20Post-COOL.pdf. Accessed March 24, 2010.

⁵ Grier (2009) explains that the price decline was primarily driven by a decline in off-shore export markets because the North American pork demand was not noticeably impacted by H1N1.

⁶ Larue *et al* (2000) and Gervais and Lambert (2010) provide a good summaries of the differences in hog marketing institutions between regions.

⁷ Packing plants processing U.S. hogs will face additional transaction costs because of COOL, yet transaction costs have only been inserted in the supply schedule of U.S. firms processing Canadian hogs. One can think of the variable τ as incremental costs faced by U.S. packers that slaughter Canadian animals as opposed to U.S. firms that do not handle Canadian hogs.

⁸ We also investigated different specifications beside double-log linear equations. The qualitative results of the paper are unaffected by the different specifications.

⁹ We have chosen not report the estimated coefficients due to the large number of different regimes that the model is estimated over and the resulting large number of coefficients. The interested reader is welcome to request these results for the authors.

¹⁰ Bai and Perron (2003) also consider partial structural change; *i.e.* models for which only a subset of the coefficients in (15) change from one regime to the next. This possibility is less interesting in our setting.

¹¹ The SupF test addresses the deficiency of the standard F test with known break points by searching over nearly all possible break points in the data. It involves computing a sequence of F statistics for split samples. Given the timing of the break is not identified under the null hypothesis of stability, the distribution of the test (and the whole family of tests when there exists a nuisance parameter under the null) must be simulated.