Canadian Agri-Food Policy Institute (CAPI)
L'Institut canadien des politiques agro-alimentaires (ICPA)
960 Carling Avenue, CEF
Building 49, Room 318
Ottawa, Ontario
K1A 0C6

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Tel: (613) 759-1902 or (613) 715-5356 **E-mail:** **jacquesy@capi-icpa.ca**
beauchampp@capi-icpa.ca

The Impacts of U.S. Crop Subsidies on Livestock Production

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Harry de Gorter
Department of Applied Economics and Management
447 Warren Hall
Cornell University
Ithaca, NY USA 14853-7801
HD15@cornell.edu

tel. (607) 255 - 8076
fax. (607) 255 – 6696

John Cranfield
University of Guelph
Department of Agricultural Economics & Business
J.D. MacLachlan Building, Room 305
Guelph, Ontario N1G 2W1

Telephone: 519 824-4120 ext. 53708
Fax: 519 767-1510
email: jcranfie@uoguelph.ca

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1. Introduction

The 2002 U.S. Farm Bill provides significant subsidy levels to U.S. grain and oilseed producers. These subsidies can lead to declines in feed prices in the United States, thereby differentially benefiting U.S. livestock producers, vis-à-vis their Canadian counterparts. Crop subsidies in the United States have increased over time while those in Canada have declined. Such subsidies can increase U.S. livestock production in several ways: increased grain supplies reduce feed prices more in the United States than in Canada; and because crop farmers who also produce livestock enjoy economies of scope (average total costs of production decline in both products as a result of sharing the same inputs), cross-subsidization of livestock occurs. Subsidies on crops cross-subsidizes livestock production in two ways: farmers are less likely to exit (or more likely to enter) because subsidies help cover fixed costs for both outputs; and it may also pay to expand output by moving down the average cost curve. In the latter case, expanded output could reduce variable costs of production, thereby offsetting any loss incurred at lower levels of output – profits on the incremental production exceed losses on lower levels of production, with the net effect being increased profitability.

This potential intra-farm cross-subsidization affects profits, and consequently can affect both the level and the location of livestock production in Canada and the United States. The broad objective of this paper is to explore the role and impact of U.S. crop subsidy programs on the level and location of livestock production in the United States versus Canada.

To this end, we address five major issues and hypotheses:

1. What is the impact of U.S. crop subsidies on prices and incomes of grain producers?
2. How do changes in farm prices of crops translate into changes in the price and farm income of Canadian grain and livestock farmers?
3. Under what conditions is there cross-subsidization of livestock operations though payments delivered on behalf of crop production?
    - Is the subsidization limited to intra-farm subsidization of livestock by crop related payments?
    - What is the resulting impact on margins in the livestock sector?
4. What are the possible impacts on the location of livestock production across North America?
    - Can trade of feeder cattle and weaner pigs be explained by this cross—subsidization?
5. What is the impact of U.S. farm programs on U.S. based grain handling companies?
    - What are the implications on the competitiveness of Canadian based grain handling firms and Canada's role in the international grain business?

Our analysis suggests that U.S. grain policies lower prices modestly in 2003-04 but significantly more in 2000-01 (up to 7 percent), if one ignores the effect of the Conservation Reserve Program (CRP) in removing acreage from production. Including the impact of the CRP has production declining in 2003-04 but up slightly if one uses subsidies in 2000-01 time periods. Moreover, the current suite of U.S. farm programs provides U.S. grain producers with the incentive to obtain the maximum return for their grain from the market and so does not confer a direct benefit to grain handlers. As well, growth in U.S. grain and oilseed exports pale in comparison to the growth in the same exports from Canada, Brazil and Argentina. Nevertheless, we find there is perfect transmission of U.S. grain prices to eastern Canada, but dampened transmission to western Canada because of the pricing policies of the CWB. Moreover, a one percent change in U.S. grain prices is estimated to change grain and oilseed farm incomes in Canada between 1.3 and two percent. While cross subsidization of U.S. livestock production via U.S. grain subsidies can theoretically occur, the potential of this actually happening is low in the U.S. hog sector, as this sector is best characterized as highly specialized in hog production. However, the degree of cross-subsidization of beef cattle production is likely higher than for hogs, but is still not a major factor influencing beef cattle production.

We also test to see if subsidies explain recent changes in feeder cattle and weaner trade patterns. We generally conclude that U.S. subsidy programs have no effect on feeder cattle exports to the U.S., but a negative effect on weaner pig exports to the U.S. The possibility that U.S. crop subsidies provide an advantage to U.S. based grain handling firms is also explored. We conclude that any impact of U.S. subsidy programs on U.S grain handling firms arises through economies of scale in grain handling (expanded U.S. grain production implies greater through put and spreading of fixed costs over a larger volume) and lower prices as U.S. subsidy programs tend to depress crop prices. In totality these two effects are thought to give the U.S. grain handling sector a competitive advantage over those in other regions.

The next section of the paper addresses the economic impact of U.S. subsidies on the grain and oilseed sector in the U.S. Combined with U.S.-Canada price transmission elasticities, results from this section are used to infer the impact of U.S. subsidies on grain and oilseed farm incomes in Canada. The theory and empirical analysis of cross-subsidization is then explored. Following this, the location of livestock production in North America is discussed, as well as the role of cross-subsidization in shaping feeder cattle and weaner pig trade. The issue of whether grain companies gain an unfair advantage from U.S. subsidies is then discussed. The last section provides a summary and conclusion to the paper.

2. Impact of U.S. Crop Subsidies on Grain Prices

Much has been written on the effects of U.S. crop subsidies on world market prices. The most often used or quoted model is that of the Food and Agricultural Research Institute (FAPRI) at Missouri (in conjunction with Iowa State's Centre for Agricultural and Rural Development - CARD)[1]. All studies take a very short run view of the agricultural sector, with supply elasticities in the order of 0.20 (when agricultural economists have generally concluded they are greater than 1.0 in the long run). The study by Gardner (2002), drawing on the FAPRI model, is one of the more carefully written and comprehensive papers on the net effects of U.S. subsidy programs on production and market prices. We draw on his approach except incorporate the economic analysis of Sumner (2003) that drove the WTO Panel's decision (WTO 2004b) on cotton that

[1] For details, see http://www.fapri.missouri.edu/index.asp?current_page=home and http://www.card.iastate.edu/research/tap/ . There are several other models as well, notably the OECD's AGLINK and USDA's PENN-USDA model.

decoupled payments in the United States were not in fact decoupled. This recent WTO Panel on U.S. subsidies is a landmark case in developing a common understanding of the effects of U.S. crop subsidy programs on output and prices. The research undertaken by Sumner was based on the FAPRI model (with the aid of Iowa State's CARD). The Panel agreed with the submissions of Brazil, in that the four major U.S. crop subsidy programs were not in conformity with the subsidy limits agreed upon in the Agreement on Agriculture.

These four programs are:

(1) Production flexibility contract payments (PFCs) – now "direct payments" (DPs) in the 2002 Farm Bill. The WTO Panel deemed these trade distorting

(2) Emergency Market Loss Assistance Payments (EMLAs) – now "Counter-cyclical payments" (CCPs) in the 2002 Farm Bill. The WTO Panel deemed these to distort production as well, albeit with a higher impact relative to category (1) above (see analysis below).

(3) Loan Deficiency Payments: recognized by all parties as fully coupled subsidies.

(4) Crop Insurance subsidies: The WTO did not make a ruling on these subsidies but Sumner (2003) deemed them as fully coupled (as we do in the analysis to follow).

The so-called decoupled payments in categories (1) and (2) above were deemed to increase output and hence distort trade in the analysis brought before the WTO Panel by Sumner (2003) for the following basic reasons:

- risk reduction effects (reduce risk by wealth effects and reduce risk aversion by reducing income volatility),
- expectation of changes in base acreage and payment yields (thereby affecting current production decisions of farmers),
- reducing credit constraints,
- land is required to be maintained in agricultural uses (and farmers are not allowed to plant fruit or vegetable crops with base acres, a further restriction that makes the payments more coupled).[2]

We analyze the effects of these programs on the wheat, feed grain and soybean markets for two different time periods: 2000-2001 and 2003-2004. This is because subsidies in 2005 are predicted to exceed those in 2000-01, with subsidies in the latter time period being much higher than in 20003-04. A summary of prices, production and subsidy levels for these two time periods are given in Tables 1A and 1B. In each time period, wheat averages the highest total subsidy per bushel ($1.17 and $0.72 in 2000-01 and 2003-04, respectively) with fully coupled subsidies (deficiency and crop insurance) over 30 cents per bushel in 2000-01 on average, for all three commodity categories, and ranging from 14 to 19 cents per bushel in 2003-04.

[2] For a recent survey of the literature on these and other potential effects of U.S. decoupled payments on crop production, see OECD (2005).

The WTO Panel's decision regarding PFCs/DPs and EMLAs/CCPs was based on Sumner's (2003) work. Relative to fully coupled subsidies (of loan deficiency payments and crop insurance subsidies), Sumner's analysis showed the following quantitative impact of PFCs/DPs and EMLAs/CCPs on production:

PFCs (low-high):	0.15 to 0.40
EMLAs (low-high):	0.25 to 0.5
DPs:	0.25
CCPs:	0.40

In other words, every dollar of PFCs had an estimated impact on output of a $0.15 to $0.40 subsidy that is a fully coupled subsidy (the corresponding range for EMLAs is 0.25 to 0.50, while DPs and CCPs had an estimated impact of 0.25 and 0.40, respectively). For example, the coefficient for CCPs of 0.40 implies that a dollar of CCP has only a 40 percent impact on production compared to a dollar of fully coupled subsidy (like deficiency and crop insurance payments). Therefore, DPs and CCPs are partially decoupled in that they have a lesser impact on production relative to deficiency payments. We combine these coefficients with an analysis of coupled subsidies along the lines of Gardner (2002) to determine an estimate of what the overall impact U.S. subsidy programs had on output and prices. To do so, we use short run elasticities from FAPRI (as Gardner (2002) and others do), with some interpretation.

Short Run Supply: elasticities ranged from 0.03 for sorghum to 0.423 for barley with an average for all crops of 0.20 (after including cross-price effects).
Short Run Demand: export + domestic demand (low-high): -0.33 to -0.5.

We use a supply elasticity of 0.2 and the highest total demand elasticity reported by FAPRI of -0.5.

Although we do not undertake a statistical analysis for long run effects, it is generally believed that short run supply elasticities are lower than demand elasticities relative to the longer run because of the nature of agricultural production: there is very little a farmer can do to increase or decrease output in the short run (whereas consumers have more flexibility in changing their consumption patterns). This means the effect of U.S. subsidies on world price effects are expected to be even larger in the long run – hence, the values that follow can be viewed as a lower bound.

<u>Empirical Results</u>

The results from our model are given in Tables 2A and 2B in terms of the percent change in production and prices. The negative impacts of all subsidies taken together on prices are 6.4, 5.7 and 7.0 percent for wheat, corn and soybeans, respectively in 2000-01 (and 2.6, 3.1 and 1.2 percent in 2003-04). Using the methodology applied in the WTO Panel ruling, including the effects of DPs and CCPs make a significant contribution to prices relative to the standard coupled subsidies. Inspection of Tables 1A and 1B shows that DPs and CCPs represent the bulk of the share of total subsidies, especially in 2003-04 (but only 33 and 7 percent of total subsidies in 2000-01 for feed grains and soybeans, respectively). Tables 2A shows that about half of the production distortion in 2000-01 is due to DPs and CCPs for wheat and feed grains but none for soybeans. Table 2B shows that 43 percent of the production distortion for wheat and feed grains in 2003-04 is due to DPs and CCPs (compared to the coupled subsidies), while 32 percent of increased soybean production is due to DPs and CCPs.

The numbers in Tables 2A are comparable to that in Gardner (2002) but are much lower for the time period 2003-04 in Table 2B. Gardner (2002) had an average price decline of around 5-6 percent.[3] Gardner (2002) used two approaches to get this result: the one used here except he assumed a subsidy rate for grains and oilseeds in 1999-2001 of 20 percent for the loan deficiency program alone. The average subsidy rates unadjusted for differential effects of DPs and CCPs are 36.2 percent and 18.7 percent in 2000-01 and 2003-04, respectively. Adjusted for their differential production distortion effects, then the average subsidy rates was 21 and 9.4 percent for the time periods 2000-01 and 2003-04, respectively.

The sources for higher subsidy rates in Gardner's (2002) analysis over our analysis for 2003-04 are the higher subsidies and lower market prices that prevailed in 1999-2001 (compared to the period 2003-2004 analyzed in Table 1B and 2B). As a consequence, Gardner (2002) has production increasing 3 percent, much higher than the average for all crops of 1.2 percent in Table 2B. But our analysis of 2000-01 is very comparable to that found in Gardner (2002). The second approach used by Gardner (2002) was a time series analysis, isolating the impacts of subsidies, given assumptions on the impact of productivity increases and market prices. Here, he determines that subsidies cause production to increase in the range of 3-5 percent, resulting in even larger price declines using the upper range of his estimates.

Although our estimated impacts of U.S. subsidies are consistent with many studies in the literature, we get lower price impacts than that determined by Gardner (2002). We adapted the economic model and parameters of the first of two approaches used by Gardner in his study and combined it with the differential degrees of decoupling among the various subsidy programs determined by Sumner (2003) in the WTO panel on cotton. We get different impacts than Gardner because of different time periods analyzed. Gardner's second approach yielded even higher price declines in the 6 to 9 percent range. One can therefore conclude that the analysis presented in Tables 2A and 2B (using the Sumner (2003) method and applied to Gardner's first model) is a lower bound of the impact of subsidy programs on production and market prices.

What of the future? Figure 1 provides the forecast for direct payments for all commodities (a commodity breakdown is not available but most payments are for the field crops). Total payments in 2005 are forecast to be 50 percent higher than 2003-04 (as analyzed here in Tables 1B and 2B). This means the price depressing effects of U.S. subsidy programs will be significantly higher, especially when market prices are lower, which will generate even higher *subsidy rates*, like in the analysis reported for the time period 2000-01 in Tables 1A and 2A.

[3] However, our numbers for 2003-04 are more in the range reported by Westcott and Price (2001) using the USDA's FAPSIM model where they find market prices decline 2.2, 1.4 and 3.7 percent for wheat, corn and soybeans, respectively.

The WTO Panel Legal Ruling

It should be noted that the WTO did not rule on crop insurance (Sumner (2003) modeled crop insurance as fully coupled) but deemed deficiency and CCPs as trade distorting (i.e., CCP's have significant world price depression effects, causing "serious prejudice"). DPs were deemed trade distorting and not incompliance with the U.S.'s WTO commitments on domestic support but the Panel did not make a ruling as to DPs making a significant negative impact on world prices (even though in theory, they are no less trade distorting than CCPs are on crop production). Analysts predict that the United States can fulfill their obligations on DPs merely by removing the restriction that fruit and vegetable production is not allowed on land receiving decoupled payments.[4] For a good summary of the WTO Panel's findings and implications, see Schnepf (2004).

The Role of the Conservation Reserve Program

For a more accurate picture, one has to also analyze the impact of acreage set-asides and acres devoted to the Conservation Reserve Program (CRP) in the United States in shifting the supply curve left, thus reducing supplies and increasing prices. Figure 2 gives a history of the acres diverted and put into the CRP for wheat, feed grains and soybeans. The CRP began in 1986 while the acreage set-asides were terminated in the 1996 Farm Bill. Currently, approximately 10 percent of total acres planted to wheat, feed grains and soybeans are in the CRP (Figure 3). A recent study by Sullivan et al. (2004) argues that only 51 percent of acres in the CRP would go back into production if the CRP was terminated. Of the acres returning to production, the yield per acre would be lower than current acres in production. Hence production would increase by less than 5 percent as a result of terminating the CRP. Nevertheless, the CRP as it now stands may be taking enough production off the market to offset the price depressing effects of the subsidies analyzed above. These subsidies involve a *movement along* the supply curve in increasing output while the CRP involves a *shift inward* of the supply curve, having an opposite impact on prices.

We can estimate the net overall effect of the output decreasing effect of the CRP versus the increasing effect of subsidies, comparing our analysis to the two methods by Gardner. Assuming 51 percent of acres in the CRP would otherwise be in production, and assuming the yield per acre is 80 percent lower for these acres, then the supply curve shifts left by 4 percent (actual supply would decrease less than 4 percent because we would move up the demand curve). We now have to determine how much the supply curve shifts due to the subsidies. Output increases 1.35 and 3.0 percent in 2001-02 and 2003-04, respectively. This is equivalent to a movement along the supply curve due to subsidies. But there is an implicit shift right in the supply curve associated with it too – in other words, if one assumes prices do not change, one can measure the implicit rightward shift in the supply curve due to the subsidies. Given the supply elasticity and subsidy rates determined in this paper, the rightward shifts in the supply curve are 4.20 and 1.90 percent in the time periods 2000-01 and 2003-04, respectively. See the Appendix 2 for a detailed discussion. This means a 4 percent shift left in the supply curve due to the CRP is not offset by the 4.20 percent shift right due to subsidies in 2000-01 but is offset by the 1.90 percent shift right

[4] Apparently the Panel failed to rule on changes in the base and payment yields, even though such changes were in clear violation of WTO rules for decoupled payments designated in the exempt "green box".

in the supply due to the subsidies in 2003-04. The net effect on the supply curve shift is +0.20 and -2.10 percent, respectively, for the time periods 2000-01 and 2003-04. This implies the net effect of U.S. crop policies in our analysis is for market prices to increase in 2003-04. This result along with the analogous evaluation of Gardner's two methods of estimating the subsidy effects of subsidies is summarized in the Table below. Our analysis of method 1 in Gardner has the CRP exactly offsetting the subsidy effect while method 2 has the subsidy effect dominating the CRP. In conclusion, the CRP may or may not offset the production enhancing effects of subsidies, depending on the subsidy rates prevailing in the time period under investigation, and on the method used in determining their effects.

Net Effect of U.S. Crop Policies on the Supply Curve*

This Study		Gardner's Analysis (1999-2001)	
2000-01	2003-04	Method 1	Method 2
0.20	-2.1	0	0 to 2.65

* Measured as the net % shift in the supply curve.

The data in the table above reflects the leftward shift due to the CRP and the rightward shift due to subsidies, holding everything else constant (including demand conditions and hence price). So the shifts due to a subsidy *versus* the CRP are isolated without bringing other factors into the discussion.

How effective has decoupling been overall?

The analysis so far concludes that the negative impacts of U.S subsidies are relatively small, especially given the existence of the CRP in withdrawing land from production. On the other hand, we can analyze the extent to which the farm bills in 1985, 1990, 1996 and 2002 reduced production by looking at time series data and comparing them to Canada.

Figures 4 and 5 plot feed grain and soybean production in the United States from 1970 to 2004. The trends in these figures suggest that policy reforms have not had the desired effect on production. Specifically, these figures provide evidence that decoupled subsidies still enhance production through the mechanisms argued by Sumner (2003) before the WTO Panel (see discussion earlier). Figures 6 and 7 give comparable data for Canada for feed grains and wheat; note that feed grain production in Canada has increased by 250 percent and by 200 percent in the United States. The introduction of price supports in the 2002 Farm Bill for protein crops (dried peas, lentils and chick peas) has generated a substantial increase in production, having grave consequences for the Canadian farmers of these crops (Figure 8 shows this dramatic effect that seems to have a hockey stick like trend in production!)

How far is the United States above WTO Commitments?

The WTO Panel found that U.S. subsidies exceed their WTO commitments in the Agreement on Agriculture. The expiration of the "Peace Clause" (article 13 of the URAA) means many agricultural subsidies are vulnerable to legal challenge under the countervailing subsidy and anti-dumping codes or with claims of nullification or impairment.[5]

The question now arises as to how much the U.S. is over the Uruguay Round Agreement on Agricultures' limits, given the WTO Panel findings on what does or does not constitute a green box subsidy for cotton. With the expiry of the Peace Clause, this has even more important implications. Figures 9 and 10 give the data for wheat and corn, respectively.[6] In both cases, the United States is over the limits (except for corn in 2002), given that the WTO Panel on cotton rules that DPs and CCPs are trade distorting subsidies.

Costs of Production relative to market prices

The Agreement on Subsidies and Countervailing Measures (ASCM) was the legal code under which the WTO Panel issued its decision on U.S. cotton subsidies. A domestic subsidy is "actionable" if shown to cause "serious prejudice" to the exports of a complaining country because it would constitute a case of "non-violation nullification or impairment of a benefit" and if no negotiated solution could be found, the complaining country would be able to retaliate -- in principle against goods in the same "sector" such as cotton, but in appropriate circumstances retaliation can go against goods in other sectors. This will be necessary for Brazil if authorization for retaliation by the WTO is eventually given to Brazil because Brazil does not import cotton.

The expiration of the "Peace Clause" (article 13 of the URAA) means many agricultural subsidies are now also vulnerable to legal challenge under the anti-dumping codes. Anti-dumping code disciplines individual firms that export products at a cost of production above the market price with anti-dumping duties (and so does not involve taxpayer funds).

To illustrate the potential for anti-dumping actions in the case of the U.S. crop sectors, consider the dumping margins (defined as the difference between the costs of production and the market (world) price) calculated for U.S. crops in Table 3. Total costs of production are compared to operating costs of production (variable costs including insurance, taxes and depreciation). Dumping margins are very high if one uses total costs of production as the comparison point (102.2 percent, 63.1 percent and 49.1 percent, for wheat, soybeans and corn, respectively), and positive only for wheat (30.4 percent) if one uses operating costs only.

These data in the first five columns of Table 3 use "average" costs for the industry. Another way to look at the issue is to see how much is being produced above costs of production (presumably possible because of the subsidies). Figure 11 gives an example for corn. The cumulative distribution of the total costs of production are given on the vertical axis while the horizontal axis represents the per unit costs and revenues. Market prices in 2001 were $1.85/bu and so are depicted by a vertical line in the graph. Two graphs are plotted: the top graph gives the

[5] For a discussion on the implication of the Peace Clause expiring, see Steinberg and Josling (2003).
[6] The Peace Clause limits were based on the 1992 baseline and the URAA disciplines were based on 1986-88 subsidy levels. We use the word "Implied" in Figures 9 and 10 because the Peace Clause expired after 2003 and because there are no individual commodity limits in the URAA.

cumulative amount of production at each level of cost. The intersection of the graph with the vertical line depicting the market price of $1.85/bu indicates that approximately 67 percent of production occurs below the total costs of production (meaning about 33 percent of corn produced in the United States in 2001 was produced above the costs of production). The bottom graph gives the same data for the number of farms. About 50 percent of the farms are operating below the cost of production. This means subsidies may be a powerful motivating factor for a significant amount of U.S. output produced above the costs of production at world market prices.

Returning to Table 3, the last two columns provide summary data for these two cumulative distributions (level of production and number of farms) relative to the market price. Like corn, a significant number of farmers do not all operate below the market price. For example, only 69.3 percent of wheat production occurs at or below the market price.

The only action for anti-dumping is to levy an import tariff (an anti-dumping duty) equal to the calculated dumping margin. This can be effective for an importer of U.S. field crops. However, unlike the ASCM under which the cotton case revolved, there is no direct remedial action available for a non-subsidizing competing exporter like Canada. Of course producers in the competing exporting country like Canada could encourage the importing country to bring an antidumping action against the dumped imports from the United States in the hope that the latter reforms its policies (with no duty on Canada's exports - otherwise, it would lower prices even further for Canadian exports)

Nevertheless, in the wake of the Peace Clause expiry, the potential use by non-subsidizing countries of anti-dumping duties will now provide the potential use of more bargaining power to contest the compatibility of domestic farm policies with more strict disciplines generally available to nonagricultural sectors in the WTO. The remedy would be the elimination of the subsidy (or the export of products below domestic costs of production) and its adverse effect.

3. Are U.S. Grain and Oilseed Prices Arbitraged into the Canada market?

The previous section illustrated how U.S. support programs can depress the price of grain and oilseeds in the U.S. Given the geographic proximity between Canada and the U.S., the relatively open border between these two countries, and their role in the world grain and oilseed markets, one might expect that U.S. grain and oilseed price changes have a bearing on grain and oilseed prices in Canada. While in-depth analysis of the price arbitrage between Canada and the U.S. is beyond the scope of this study, we can examine various price transmission elasticities between Canada and the U.S. to determine the extent to which a decrease in U.S. prices will affect Canadian prices.

In what follows, the price transmission elasticities for barley, corn and soybeans are considered. These commodities have been selected as two of them tie directly into the previous section's analysis (i.e., corn and soybeans), and all three are used extensively in animal feed rations in Canada. In this regard, note that Agriculture and Agri-Food Canada's FARM model uses the price transmission equations whose coefficients imply the following price transmission elasticities between U.S. prices and the respective Canadian price (evaluated using average data from 1997 to 2003):

Barley:	Western Canada: 0.785
Corn:	Western Canada: 0.809
	Eastern Canada: 1.078
Soybeans:	Eastern Canada: 1.013

For eastern Canada, these price transmission elasticities are effectively one, while those for western Canada are far below unity. It is important to emphasize that we do not presume these price transmission elasticities are affected by U.S. subsidy programs. Indeed, it is contended here that those in western Canada are more inelastic because of marketing institutions, namely the Canadian Wheat Board. Specifically, the CWB is the single desk seller for most of the grain produced in the three prairie provinces. The single desk selling function, in conjunction with the quality premiums associated with Canadian wheat, will tend to dampen the impact of U.S. grain price movements in western Canada.[7,8] The observed values in eastern Canada reflect the fact that grain companies in the east typically price off U.S. commodity exchanges surrounding the great lakes.

The role of these price transmission elasticities cannot be understated. A change in the price of a U.S. crop will affect the price of the corresponding Canadian crop via price transmission. This means subsidy induced reductions in grain and oilseed prices in the U.S. (see Table 2) will lower the corresponding price in Canada. However, the extent of these reductions in Canada will vary by region. Prices in western Canada appear less responsive to U.S. price changes then prices in eastern Canada. All other things being equal, this means incomes of grain and oilseed producers in western Canada would not be as negatively affected by U.S. support programs as those in eastern Canada. In contrast, the same price reduction in the U.S. will have a differential effect across livestock producers in Canada – livestock producers in western Canada would experience a reduction in feed grain costs, but to a lesser extent than those in eastern Canada.

To illustrate the role these price transmission elasticities play, consider the impact of U.S. subsidy payments on Canadian grain and oilseed producers. To begin, let us take the simple average of the change in price for all commodities shown in Table 2B for 2003-04 (which is 2.3 percent under the all subsidies scenario). This means U.S. subsidies have reduced grain and oilseed prices in the U.S. by about 2.3 percent. We can use this reduction, in conjunction with the regional price transmission elasticities in Canada and an assumed long run grain and oilseed supply elasticity of one to estimate the increase in grain and oilseed producer incomes in Canada if the United States eliminated their subsidy programs.

First, note that the U.S.-eastern Canada price transmission elasticities are effectively one, while the average of the U.S.-western Canada price transmission elasticities is 0.797. This means a 2.3

[7] We would note, however, that debate continues regarding whether the CWB actually increases the price of local cash prices for grain in western Canadian. It may well be that the western Canadian grain prices could have been lower without the CWB. If this were true, one might conclude that the western Canadian livestock producers have been cross subsidized by the activities of the CWB. Nevertheless, this is an issue far beyond the scope of the current analysis.

[8] One reviewer disagreed with our assessment of the role of the CWB in shaping the western Canadian price transmission elasticities. This reviewer further stated that if the eastern Canadian price transmission elasticities were effectively unity, then so too should the western Canadian price transmission elasticities.

percent increase in grain and oilseed prices in the U.S. will result in an identical increase in grain and oilseed prices in eastern Canada, but a 1.83 percent increase in western Canada (the latter is simply the product of the U.S. price increase and the U.S-western Canada price transmission elasticity). In 2002, farm cash receipts in eastern and western Canada were $1.695 and $6.01 billion, respectively, for grains and oilseeds. Assuming a long run supply elasticity of one, for convenience, the change in farm cash receipts (i.e., revenue) can be calculated as the base revenue times a term that involves the percent change in price.[9] Combine this with the price transmission elasticities and percent changes in U.S. grain and oilseed prices, and one would see that grain and oilseed farm cash receipts in eastern Canada are expected to increase by nearly 4.65 percent, to $1.77 billion, and by 3.7 percent to $6.23 billion in western Canada.

How do these farm cash receipt values relate to farm income? This can be answered by recognizing that producers' surplus can provide a reasonable approximation to farm income. When the supply elasticity is unity, producers' surplus is simply half of revenue. As such, producer surplus in eastern Canada would increase by $39 million ($29 million if the supply elasticity was assumed to be 0.5), while that in western Canada would rise by $111 million ($83 million with a supply elasticity of 0.5). Taken together, these changes represent an increase in Canadian grain and oilseed farm income of $150 million, or 3.9 percent. Loosely put, this implies a one percent change in U.S. grain and oilseed prices generates between a 1.3 and 1.7 percent change (in the same direction) in Canadian grain and oilseed farm income. If the western Canadian price transmission elasticities equal unity (see footnote 8), then the 2.3 percent change in U.S grain and oilseed prices changes Canada grain and oilseed producer surplus by $180 million ($134 million with a supply elasticity of 0.5). The implication being that a one percent change in U.S. grain and oilseed prices changes Canadian grain and oilseed producer income anywhere between 1.51 percent and about two percent.

For a given supply elasticities, these grain and oilseed income changes represent a lower bound. To see this, note that if one used Gardner's second method to calculate the price effects, then the impact of U.S. subsidies on U.S. crop prices would be two to three times larger than those reported here (in Tables 2A and 2B). Moreover, differences in subsidy rates and prices across different time periods will affect the measured impact of subsidies on prices. It is not coincidental that Gardner measured a stronger impact of U.S. support program payment on prices than we do; Gardner used a period (1999-2001) which saw higher subsidies and lower market prices than the period used here (2003-2004). As such, increasing the price effect of U.S. farm programs to be more in line with 2005 record payments (see Figure 1) and those of Gardner's higher price impacts, then one could image the impact of U.S. support programs on Canadian farm income (at least grain and oilseed farm income) to be double or triple those reported here, depending on whether one thinks the price impacts are double or triple our

[9] More precisely, when the supply elasticity is unity, revenue is multiplied by $((1+\delta)^2-1)$, where δ is the percent change in price. To see this, note that the change in revenue equals $P_1Q_1-P_0Q_0$, where P_i is price, Q_i is quantity, i=0 is the base case and i=1 is the case when price changes by δ percent. Moreover, when the elasticity of supply is unity, $P_1=P_0*(1+\delta)$ and $Q_1=Q_0*(1+\delta)$. Consequently, $P_1Q_1= P_0*(1+\delta)*Q_0*(1+\delta)$, so the change in revenue equals $P_0* Q_0*((1+\delta)^2-1)$. The generalization to the case where the elasticity of supply is something other than unity is straight forward.

estimates (as our estimates are in the bottom range of Gardner's estimates).

Unfortunately, the complex relationship between the crop and livestock sector precludes undertaking such analysis for the latter. Sufficed to say, however, increased feed costs would, all other things being equal, work to reduce livestock producer incomes. Note, however, that regionally differentiated price transmission elasticities might place western Canada in a favourable position regarding cattle and hog finishing (since feed prices will not increase to the same extent as in eastern Canada).

4. Cross-subsidization - Theory

Cross-subsidization happens when you receive subsidies on only part of your output. 'Partial' output for which subsidies are received may refer to infra-marginal production for a single commodity farm or the production of one of two or more commodities produced (i.e., there are subsidies for crops, but the farm also produces livestock, the case considered in this paper). Cross-subsidization occurs if farmers are required to produce in order to receive the subsidies (or are not allowed to produce specific products; e.g., fruit and vegetables, and are required to both keep their land in agricultural production and be bona fide farmers). There are two key components to cross-subsidization: subsidies affect the exit/entry decision of the farm; and given that the farm decides to produce the amount for which subsidies are received, the farm may expand output beyond that at the market price, but at a loss. The farmer is willing to lose money on the extra output because there are cost savings for the original level of output (because average cost of production is now lower as output has expanded) that exceeds the losses on the extra output. So subsidies can affect both the decision to be out of production or produce at the level for which subsidies are received, and the decision to expand output to where the market price equals marginal costs but at a loss. One can evaluate the effects of subsidies on both short run or long run production decisions (in the short run, the farm need only cover variable costs while in the long run, total costs need to be covered by market revenues plus subsidies).

If a crop-livestock farmer has shared fixed inputs or jointness of costs between crops and livestock (like land, interest, insurance, taxes, labor, buildings, etc.), then crop subsidies can cross-subsidize livestock production. In this case, a firm enjoys economies of scope where average total costs of production decline in both products as a result of sharing the same inputs. Before we analyze the alternative situations in which cross-subsidization can occur, perhaps a more tangible example related to financing and the cost of capital would help (where interest payments on debt is counted as a joint fixed costs). Suppose a crop producer receives a subsidy such that their crop revenue plus the subsidy exceeds crop related costs.[10] This additional profit could be viewed as additional capital which could be ploughed back into the operation (assuming the operator has already extracted a return for themselves). Specifically, the additional capital could be used to finance entry into a livestock operation, expansion of an existing livestock (and/or crop) operation or to forestall exit from the industry.

The producer can use this additional "new" capital as leverage in financing an entry or expansion decision, or they could leverage the additional "new" capital to lower their financing costs of

[10] However, we show below that positive profits at the infra-marginal level of output are not necessary for cross-subsidization to occur.

working capital. This financial leverage serves the role of reducing financing costs generally, which would work to lower fixed costs across the entire operation (where financing is assumed to be a fixed cost). This suggests the firm enjoys economies of scope in financing and decoupled crop subsidies helps to lower the costs of production. What if the subsidy does not generate additional capital? In this case, the subsidy may still bring about economies of scope in financing if it works to lower the cost of working capital. In addition, if the leveraging hypothesis holds, then fixed costs would fall and (all other things being equal) total costs would also fall. The latter potentially places U.S. producers in a more advantageous cost structure position than before, and potentially more advantageous position compared to producers in other countries.

We now turn to the alternative situations in which cross-subsidization can occur. Let us consider cases only where the market price is below the average total costs of production (otherwise, subsidies on output below free market levels cannot affect the output decisions of the farmer).[11] We will see that the market price can be below or above the average variable costs of production. There are four general cases to consider (see Appendix 1 for a more detailed presentation):

Case 1:

Assumptions:

(a) Farmers make a profit on output that receives the subsidy
(b) Average variable cost of production (at the output level where the market price equals marginal costs) is less than the market price[12]

The farmer will also produce beyond the base amount for which subsidies are received (and incur losses at the free market level of production) in both the short and long runs. Why is that? Given the two assumptions above, it always holds that when a farmer expands production beyond the amount for which subsidies are received, the gain from increasing returns (the cost savings on the initial amount of output) is greater than the losses from producing the extra amount of output (for a detailed explanation with graphical analysis, see the summary at the end of Appendix 1 for this case).

So what is the implication for a grain-livestock farm? Think of the infra-marginal output receiving subsidies as total crop production on the farm (so for now it does not matter if crop subsidies are coupled or decoupled). The extra output can be considered as livestock production. There are at least economies of scope in that fixed costs are shared between the crop and livestock operations (own labor and managerial skills, land, buildings, capital equipment, insurance, etc.). Economies of scope are in addition to economies of scale for those fixed inputs that are not shared or are shared but not fully.

[11] This means we are analyzing production decisions only on the downward sloping part of the average total cost curve for cases evaluated in Figure A2 (we ignore outcomes where the price is above average total costs (ATC) because cross subsidization cannot occur for farmers in such situations).
[12] This means the farmer will produce at the free market level of output in the short run because variable costs are covered.

Given our assumptions that market revenues from both livestock and crop production are above the total variable costs of production, subsidies do not affect the farmer's decision in the short run. But in the long run, the farmer may not be in business without the subsidies. Not only is the farmer in business in the long run because of the crop subsidy, he also expands the level of livestock production where the losses of expanded output is less than the gains from economies of scope (average costs go down for crop and livestock production together). So coupled subsidies like loan deficiency payments and crop insurance subsidies will affect output, given the economic conditions described above for this particular case. So-called "decoupled" payments (like the direct and countercyclical payment programs) will have the same impact with economies of scope and the requirement that farmers have to produce to get the crop subsidies (or keep land in agricultural use and be a bona fide farmer). If there are economies of scale in crop production as well with fixed inputs that are shared, then coupled payments will have a lesser impact on cross-subsidizing livestock production. This is because coupled grain subsidies will necessarily lead to an increase in grain output, and if there is at least imperfect joint-production between crop and livestock production, competition for resources will result in less livestock production relative to a decoupled subsidy.

<u>Case 2:</u> Assumptions are the same as Case 1 except farmers incurs losses at the subsidized level of joint output (but still covers variable costs so would be in production in the short run).

The farmer will expand production of both livestock and crops in the short and long run if the cost savings from increasing returns are greater than the extra costs at the expanded level of output not being covered by revenues at the market price. In other words, the firm is losing at the infra-marginal level of output and will expand output if it loses less. It will increase output beyond the base if the revenues above the new average total costs at the infra-marginal output are greater than the extra costs at the expanded output that are not being covered by revenues at the market price. Otherwise, in the long run, the firm will exit the industry.

<u>Case 3:</u> Assumptions are the same as Case 1 except the farmers' average variable costs of production (at the output level where the market price equals marginal costs) are less than the market price.

As in case 1, the farmer makes profits at the infra-marginal output levels receiving subsidies in the short and long runs at B.

The farmer will expand production of both livestock and crops in both the long and short runs if the cost savings from increasing returns not covered by subsidies and market revenues is greater than the extra costs at the expanded level of output not being covered by revenues at the market price (including now the variable losses). In other words, if the gain from increasing returns (the cost savings on the initial amount of output) is greater than the losses from producing the extra amount of output, the farmer produces the extra amount of output and so is cross-subsidized. Otherwise, the farmer stays at the infra-marginal level of output (where, by assumption, he makes profits).

Case 4: Assumptions are the reverse of Case 1: farmers incur losses at the subsidized level of joint output (but still covers variable costs so would be in production in the short run) and average variable costs are below market prices.

In the short run, the farmer stays at the infra-marginal level of subsidized output only if the revenues above the new average total costs at the infra-marginal output are greater than the extra costs at the expanded output that are not being covered by revenues at the market price (including the variable losses). Otherwise, in the long run, the firm will exit the industry.

Cross Subsidization – Empirical

How significant are the effects of crop subsidies on livestock production? To our knowledge, there have been no studies undertaken in this regard. It would be a huge undertaking to determine empirically the effects of subsidies on output, especially on livestock production because economies of scope would have to be modeled. This is an important issue that future research is to determine, given the many sectors with such programs in the United States, European Union and Canada, especially given the recent WTO Panel decision on Canadian dairy and EU sugar policies facilitating cross-subsidization of exports (WTO 1999; 2004a).

There has been an empirical study on infra-marginal subsidies on crop production alone by Chau and de Gorter. If one looks at so called "decoupled" payments, PFCs alone or EMLAs alone generally do not cover fixed costs, but data suggest that the sum of these payments may have offset fixed costs for most commercial U.S. wheat farms in 1999. Although technically PFCs (now DPs) require no production, one has to be a "farmer" to receive payments and land has to be kept in "agricultural uses". Thus PFCs are an incentive to prevent some land from being converted to non-agricultural uses. Farmers may also not get PFCs if they plant fruit and vegetable crops on their historical base area.

Empirical analysis by Chau and de Gorter on the distribution of fixed costs across individual wheat farms in the United States estimate the output and export consequences of three policy scenarios: the removal of LDPs, PFCs, and both. They estimate that the removal of PFC payments in 1998 would have resulted in an exit of 3.4 percent of wheat farms and a decline in wheat production of 3.4 percent. Clearly, these results are sensitive to the distribution of PFC payments across farm size, along with the reservation profit of the individual farm. The removal of LDPs decreases exports by 56 percent while the removal of PFCs reduces exports by 41 percent. Hence, the removal of decoupled payments can have a relatively large impact on the exit decision for low-profit farm units. The aggregate impact on output can remain quite limited so long as the output level of the marginal *farm* is relatively small. If existing income payments generate an expectation of future payments that compensates short-term losses, the reservation profit of the marginal farm may take on a negative value and the aggregate output and export distortion of decoupled payments can accordingly be considerably larger. Note also that coupled subsidies are more output distorting in the absence of an exit option, but decoupled subsidies are nevertheless more effective in deterring exit for a given gross transfer to farmers because economic inefficiency due to "coupling" do not arise.

Direct income payments can help offset fixed costs that are often a significant proportion of total costs. Agriculture is generally believed to be a "fixed costs" industry so the issue of cross-subsidization can be of importance. Data in Table 4 shows fixed costs to be higher than variable costs for all crops listed. Fixed costs are about 50 percent higher than variable costs for wheat. The fourth line gives market revenue and clearly does not cover total costs. But the last line of Table 4 shows that government payments do not cover full economic costs in all cases, except for corn in 2003 and soybeans in 2002 and 2003. Hence, there is evidence that government payments can deter exit and induce entry into farming or crop production.

However, this data does not refer to farms with joint crop-livestock production. Data on livestock producers that receive government payments for crops produced on their farm is given in Table 5. Fixed costs are 35.3 and 30.6 percent of total costs for beef cattle and hog farms, respectively. This shows fixed costs are significantly lower than crop farms alone. Government payments as a share of fixed costs are rather low, especially for hogs (7.6 percent). Government payments as a share of total revenues for beef cattle and hog farms are even lower, amounting to only 3.8 percent for beef cattle and 1.3 percent for hog farms.

The lower values for hogs reflects the very specialized nature of hog production in the United States, with contract farming and other forms of vertical integration. This leads us to conclude that cross subsidization of livestock from crop subsidies, although very possible in theory, is unlikely to have a major impact on hog production in the real world, and perhaps not even on beef cattle production.

5. Impacts on the location of livestock production across North America

It is important to understand that the location of Canada's livestock sector, especially the cattle sector, has been shaped by government regulation, in addition to the traditional economic forces that give one region a comparative advantage over other regions with respect to resource utilization.[13,14] Beginning in the late 1890s, Canada regulated freight rates in western Canada via the Crow's Nest Pass Agreement. Regulated freight rates were set at a level less than the actual cost of shipping product out of western Canada. For grain, reduced freight rates meant grain flowed out of western Canada, typically destined for export via west cost ports or shipped to eastern Canada, either for export, human consumption or as livestock feed. Consequently, limited supplies of feed-grains in the west slowed growth of western Canada's livestock sector.

However, overtime, the gap between regulated freight rates and the actual cost of shipping grew. This eventually led to replacement of the Crow's Nest Pass Agreement with the Western Grain Transportation Act (WGTA). Under the WGTA, railways were guaranteed a 20 percent return to their fixed costs (Schmitz et al 2002). Moreover, under the WGTA, the federal government subsidized transport of grain out of western Canada (via direct payments to railways). By the early 1990s, the cost of the WGTA had grown significantly, and the program was viewed as an

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[13] Much of this beginning discussion draws from Le Roy and Klein (forthcoming)

[14] Beaulieu and Bedard (2003) provide a geographic analysis of livestock production in Canada from 1991 to 2001. Unfortunately, their paper focuses on the changes in livestock production patterns, rather than the causes. Nevertheless, it does provide an interesting backdrop.

export subsidy. By 1995, the federal government eliminated the WGTA entirely. Consequently, the impetus to ship grain out of western Canada weakened significantly.

Another policy (actually regulation) may have had an effect on the western livestock sector, namely seed variety regulations. In particular, seed varieties must go through an extensive approval process that tends to favour those varieties which garner a (higher) premium in the international market. As these varieties also tend to be destined to the human food chain, their growth in western Canada can "crowd-out" seed varieties better suited for feed, thus creating the potential for feed deficits in western Canada. Such a deficit could provide the impetus to ship feeder animals out of western Canada rather than fed animals.

Nevertheless, concurrent with the WGTA, the province of Alberta instituted several programs designed to offset the cost of feeding livestock (these programs were the Alberta Feedgrain Market Adjustment Program and the Alberta Crow Rate Benefit Offset). These programs spawned growth of the cattle sector in Alberta. By the late 1980s, the government of Alberta had also provided funds to Cargill to establish a beef slaughter and processing facility in High River, Alberta.

While the incentive provided to Cargill helps explain their location decision, it is also important to note that the cattle sector in Alberta had begun to grow substantially by this time. As such, Cargill's location decision could also be explained by pure economics – Alberta (and the west as a whole) had an abundance of feed-grain. Consequently, the livestock sector gravitated to the west to take advantage of less costly feeds.

Elimination of the WGTA and expansion of the western livestock sector also helps explain the expansion of other cattle processing facilities in western Canada. Most noticeable among these is the IBP (formerly Lakeside Packers) plant in Brooks Alberta. Together the Cargill and IBP plants account for the lion's share of total cattle slaughter in Canada (the other significant player in Better Beef in Guelph, Ontario).[15] Note that both the Cargill and IBP plants can add additional shift(s) to meet demand, so it is unlikely that additional processing capacity will emerge in the near term, especially in light of BSE and its consequences (i.e., excess capacity). As a result, one might safely conclude that the processing cattle sector will not change its relative geographic position in Canada.

At the same time, the location of the processing sector and economics of shipping grains versus meat would suggest that the location of cattle production in Canada will not change appreciably (i.e., cattle production will largely remain in western Canada). It is important to note, however, that if trade actions taken by other countries after the discovery of a BSE infected bovine animal in Alberta remain, the Canadian beef industry may produce for a largely domestic audience. If this occurs, it may well be that production patterns shift to reflect location of feed-grains and location of large demand centres (i.e. large urban centres).

With respect to the hog industry, recognize that the nature of swine feed rations engenders itself to production locations distributed across Canada. Swine can be fed barley (which tends to be

[15] It should be noted that, pending approval by the Competition Bureau, Cargill Inc. has agreed to purchase Better Beef.

better suited to western Canada) and corn (which tends to be better suited to eastern Canada) for energy and protein supplements which can include soybean or canola meal (canola can be grown in western and eastern Canada, but tends to be more prevalent in the west). Hogs in western Canada are typically fed barley and canola meal, while eastern Canada hog feeders typical use corn and soybean mean. Nevertheless, several factors contribute to the pattern of hog production in Canada. Naturally, the discussion related to the impact of rail transport regulation, the WGTA and feed-grain availability applies to hogs (i.e. lower cost feed-grains attracts livestock production). However, hog production tends not to be as geographically concentrated as cattle production, largely due to the range of feed substitutes hogs can consume.

As well, the location of hog production capacity also helps to explain the location of hog processing. Maple Leaf opened a large hog slaughter and processing facility in Brandon Manitoba in 1999. It should be noted that the Brandon plant effectively replaced an older hog processing plant in Edmonton Alberta, and that the decision to locate in Brandon was based in part on incentives provided by the local government, availability of feed-grains and growing hog production capacity. Moreover, Brandon offers a unique locational advantage, being close to the geographic centre of North America. Also note that Maple Leaf's Brandon MB plant recently received approval and environmental licenses to operate double-shifts (Haley, 2004, footnote 10). Given this plant's capacity (40,000 hogs per week), such a change would further cement this facility as a focal point of hog processing in Canada.

Significant hog processing capacity also exists in Ontario and Quebec (in fact, Quebec accounts for the largest share of Canadian hog slaughter). Given the historic location of plants in Ontario and Quebec, and the access these plants have to large market areas, it is not likely these facilities will move in the near future. As with cattle, given the economics of shipping grain versus meat, inertia of hog slaughter and processing facilities will translate into inertia of hog production.

One issue that cannot be over-looked regarding hog production relates to subsidy programs in Quebec. Quebec has historically offered a suite of provincial farm subsidy programs (e.g., Quebec Farm Income Stabilization Insurance Program). It is widely recognized that these programs have profoundly influenced the size of this province's hog production sector. Namely, they have resulted in expanded production capacity (and also resulted in countervailing duties). Moreover, a firmly cemented hog production sector has attracted a hog processing sector which, once in place, and given the relatively large investment needed to establish a new facility, tends not to move.

One last issue that may also fix the location of livestock production within Canada is environmental regulations. Some regions have begun to implement regulations and acts that tie one's ability to dispose of livestock waste to one's land base (e.g., the Nutrient Management Act in Ontario). At the same time, some regions are also enacting approval processes related to establishment of livestock production facilities (e.g., some municipalities in Manitoba have been scrutinizing establishing of new production facilities). The latter will work to prevent (or limit) the extent to which de novo livestock production facilities can be established, while the former will limit the extent to which existing facilities can expand production.

In general terms, the pattern that has emerged with respect to livestock production is one where livestock production facilities settled in regions with favorable feed-grain balance, with processing faculties following suite. The often cited phrase, livestock production follows grain and livestock processing follows livestock production, rings true here. It is important to note that the historic production pattern in Canada, especially with respect to cattle, has largely been shaped by government programs, while the location of livestock processing facilities has been shaped not only by economics, but also by incentives provided by local and regional government. As processing faculties represent a significant investment in capital, it is unlikely the location of livestock processing will change in the near to medium run (and perhaps beyond). Moreover, as shipping technology enables movement of meat over long distances (without compromising quality), but the same is not true if live animals, it is unlikely that livestock processing and production will shift relative to its current spatial pattern.

Recognize that the location of livestock production in Canada also has a bearing on Canada-U.S. livestock trade. In this regard, the locational pattern of U.S. livestock production cannot be over looked. Herath, Weersink and Carpentier (2004) examined the spatial and temporal changes in U.S. livestock production using measures of scale (specifically inventory levels) and concentration. Results from their study indicate that livestock production moved out of the northeast U.S. (which included the Great Lakes, New England and mid-east areas) to other parts of the U.S. The scale and concentration of hog production increased in the southeast U.S. and corn-belt states, while fed-cattle production scale and concentration increased in the Great Plains and southwest regions.

Evolution of the hog industries in Canada and the U.S. has resulted in various efforts to better understand the linkages between these two sectors. Recently, Haley provided an analysis related to market integration of the North American hog industry. A number of points stand out from her analysis:

- trade in live hogs has increased since 1990, with much of this growth driven by increases in swine weighing less than 50 kilograms (which would typically be weaner or feeder pigs which will be fed to slaughter weight in the U.S.) and swine weighing more than 50 kilograms for immediate slaughter

- most U.S. hog imports from Canada enter via Michigan and North Dakota and are destined to states in the corn belt, western great lakes and Great Plains regions,

- an increasing proportion of U.S. live swine imports are feeder (or weaner) pigs,

- 23 percent of total feeder pig movement in U.S. is accounted for by feeder pigs originally from Ontario and Manitoba.

Haley provides analysis and discussion explaining why the observed trends have occurred. In this regard, show notes the adage “livestock follows grain” holds true in the U.S. hog sector – namely, hog production has settled in regions where feed-grains are readily available, and that the processing sector has followed live hogs. She also notes the importance of exchange rates in shaping trade flows vis-à-vis Canada. Specifically, the period 1996 to 2002 saw unprecedented appreciation of the U.S. dollar relative to the Canadian dollar. This appreciation provided the incentive to expand production, and with this, came growth in live hog exports to the U.S.

Haley also recognizes the role of feed-grain related policy changes in Canada. As with beef-cattle, policy changes related to grain transport has provided the incentive to expand hog production (as mentioned above) in western Canada. In this regard, Manitoba has emerged as an important provider of live hogs, especially feeder (or weaner) pigs. Comparative advantage, location and the climate of the Canadian prairie makes Manitoba ideally suited to provide feeder pigs to the U.S. However, given the presence of the Maple Leaf hog plant in Brandon, it seems paradoxical that Manitoba exports a large quantity of feeder pigs (as opposed to feeding, slaughtering and processing them in Manitoba). Haley explains this largely through specialization and economies of scale in the vertically integrated hog sector. U.S. producers have specialized in finishing hogs; this specialization has meant U.S. hog finishers have begun to look to Canada for feeders (specifically to Ontario and Manitoba), with the end result being increased exports of feeder (weaner) pigs from Canada. Given the growth in weaner pig exports from western Canada (especially Manitoba) and the presence of the recently opened Maple Leaf plant, one might conclude that competitive pressures will result in further growth of western Canada's hog sector. One open question at this point is whether countervailing duty issues in the hog-pork complex will vex attempts by Canadian producers to tap into the U.S. market.

Regarding live cattle trade between Canada and the U.S., it is important to recognize that events stemming from detection of two BSE infected animals in Canada are likely to continue in the future. As evidence of this, note that recent efforts to open the Canada-U.S. border to trade of live cattle under 30 months of age were forestalled by U.S. cattle lobby efforts, with no clear end in sight. At the very least, trade of meat from cattle less than 30 months of age will continue. One additional speculation is that BSE related trade actions may provide the incentive for Canadian producers to export feeder cattle (as opposed to fed cattle) to the U.S. once the border opens. The U.S. market may be more accepting of young Canadian feeder cattle as it means U.S. cattle finishers have greater control over what they feed young animals; presumably this may boost consumer confidence related to the U.S. beef industry.

That said, the impact of U.S. country-of-origin labeling cannot be ignored, as it holds the potential to limit Canadian exports of live cattle to the U.S. One question that naturally comes to mind in the context of this study is whether U.S. subsidies impact on the trade of feeder cattle and weaner pigs between Canada and the U.S.

Impact of cross-subsidization on feeder cattle and weaner pig trade

Trade of feeder cattle and weaner pigs between Canada and the U.S. tends to be one-directional. Specifically, feeder animals flow from Canada to the U.S. While Canada does import some feeder cattle and calves, these volumes tend to be very small and sporadic. Consequently, it will be difficult to measure the impact of cross-subsidization on U.S. exports of feeder animals to the Canada.

However, a large volume of both feeder cattle and calves and weaner pigs flows from Canada to the U.S. Figures 12 and 13 illustrate the volume of this trade from 1998 to 2004. Feeder cattle and calf exports to the U.S. have varied over the seven years in the sample, with a peak in 2002 (due almost entirely to exports of feeder cattle and calves from Manitoba to North Dakota). Also note that feeder cattle and calf exports fell to near zero levels in 2004, a result of the ban on imports of live cattle from Canada. Those feeders that were exported in 2004 were from British Columbia to Washington State. Weaner pig exports have shown steady growth from 1998 to 2004, most of which arose due to exports from Manitoba and Saskatchewan to North Dakota, and from Ontario to Michigan.

The explanations for feeder animal trade flows and the effect of support programs on the volume of trade become important questions. Clearly, economic fundamentals are important. Trade theory tells us that product flows from regions of low price to regions of high price. In this regard, feeder animals (whether swine or bovine) will be drawn to markets where their relative economic value is greatest. This would imply that trade of feeder animals depends on the animal's price and feed prices in both the exporting and importing regions.[16] Such a formulation would account for the relative economic benefits of feeding. Note that the feeder price variable for the exporting (importing) market is expected to be negative (positive), while the feed price effect in the exporting (importing) market is expected to be positive (negative). While feed prices could be affected by cross subsidization (which would reflect an indirect market level cross-subsidization effect), it is conceivable that support programs could also have a direct effect on trade flows. In this regard, it is important to account for the support programs not only in the U.S., but also in Canada. Canada, after all, also has various support programs that could cross-subsidize animal feeding. Naturally, the flow of animals will depend on exchange rates (as discussed in Haley).[17]

To determine if cross-subsidization impacts on feeder cattle and calf and weaner pig exports from Canada to the U.S., two separate regression models were developed (one for feeder cattle and calves, the other for weaner pigs). For each type of animal species, exports from Canada to the U.S. were regressed on an intercept, the ratio of the price of the feeder animal to feed price in both the U.S. and Canada, the CND-U.S. exchange rate, dummy variables representing the different combinations of Canadian provinces and U.S. states of entry, and variables measuring the level of government support in Canadian and U.S. agriculture. Table 6 lists the series used and their summary statistics, while Table 7 lists the government support programs used in calculating the aggregate level of support. Note that the Conservation Reserve Program was not included in the U.S. support measure, as this program takes land out of production.[18]

[16] One could argue that what actually matters is the value of gain from feeding. In this regard, it is conceivable that the price of the fed and feeder animals ought to be accounted for, or some feeding margin. However, market forces are at play which could result in the value of any fed-animal price increase (or decrease) being bid into the price of the feeder animal. In such a case, the price of the feeder animal would capture the information available in the market place and would be the appropriate term to include. In this regard, one would view demand for feeder animals as a derived demand based of demand for fed-cattle and a margin (i.e., feed costs).

[17] The relative size of the respective markets could also be important in shaping feeder animal trade flows. An effort was made to include lagged breeding herd inventories as an explanatory variable. The rational for including lagged breeding herd inventories is that they will reflect the supply response to expected future prices and size of the market. However, efforts to include the breeding herd inventory were confounded by technical problems related to the estimator and so these efforts were abandoned.

[18] Note, however, that similar regression results were obtained when the CRP was included in the U.S. support program variable. Also note that while it would beneficial to separate out crop and livestock payments, time constraints precluded such activity.

Since Agriculture and Agri-Food Canada provide feeder animal trade flows through various states of entry into the U.S., the trade flow data actually take the form of a panel data set. Specifically, feeder animal trade flows are available from 1998 to 2004 and delineated by the source province and state of entry combination. For each source province-state of entry combination (of which there are eight: BC-Washington state; Alberta-Idaho; Alberta-Montana; Manitoba/Saskatchewan-North Dakota[19]; Ontario-Michigan; Ontario-New York; Quebec-Vermont; Atlantic provinces-Vermont), there are seven years of data. Thus, each regression model has 56 observations, with each panel having seven years of data.

The model was estimated as a fixed effects model using the POOL command in SHAZAM, with a heteroskedastic consistent variance covariance matrix and, in the case of weaner pigs, allowing for first order auto-correlation. Fixed effects represent the source province-state of entry combinations (the BC-Washington State fixed effect is omitted to avoid the dummy variable trap). Table 8 shows the regression results for both the feeder cattle and calf, and weaner pig equations.

For both the feeder cattle and calf and weaner pig equations, prices effects have the expected signs. In both species' equations, the coefficient on the ratio of feeder price to feed price in Canada is negative, while the coefficient on the corresponding variables in the U.S. are positive. An increase in the economic incentive to feed animals in Canada (either through increased feeder prices or decreased feed price in Canada) reduces the volume of feeder animals exported to the U.S. By the same token, an increase in the economic incentive to feed animals in the U.S. (either through increased feeder price or decreased feed price) increases the volume of feeder animals exported to the U.S. The value of the export elasticities with respect to U.S. and Canadian feeder to feed price ratios are within the realm of reason, and suggest that the U.S. price effect is stronger than the Canadian price effect.

The exchange rate effect in the feeder cattle and calf equation is significant and has the expected sign, while that in the weaner pig equation is significant, but has an unexpected sign. Exchange rate elasticities range from very elastic in the feeder cattle and calf equation to less elastic in the weaner pig equation. While useful from a modeling device, the fixed effects are not economically informative, as such, results with respect to these intercept shifters are not discussed.

Of primary importance, however, are the support payment effects. In the feeder cattle and calf equation, the coefficient on the U.S. support payment variable is negative but not statistically different from zero, while the coefficient on the Canadian support program variable is negative and statistically significant from zero at the five percent level. For weaner pigs, the U.S. support program variable is negative and statistically significant, while the Canadian support program variable is positive and significant.

[19] The data actually differentiate between Saskatchewan-North Dakota trade and Manitoba-North Dakota trade. However, these data are constructed in fixed proportions, based on Saskatchewan's and Manitoba's share of exports to North Dakota. Consequently, the Manitoba and Saskatchewan trade flows are aggregated.

The sign on the U.S. support variables is somewhat puzzling. A priori, one could image this variable being positive – increased support in the U.S. offers cross-subsidization which stimulates feeding of animals. If a portion of the incremental animals on feed originate in Canada, one would expect a positive sign between Canadian exports and U.S. support program payments. However, if U.S. support payments rise, and there is an output effect in the U.S. domestic livestock sector (i.e., the breeding herd expands), then U.S. imports of Canadian feeder cattle and calves and weaner pigs could actually fall. While examining this hypothesis further is possible, it also entails developing a North American livestock sector model that fully accounts for supply response. While such endeavor is far beyond the scope of this study, it is an area in need of further investigation.

Nevertheless, broad conclusions can be drawn from this analysis. Specifically, cross-subsidization appears to have an effect on weaner pig trade. U.S. support program payments are negatively related to weaner pig exports from Canada to the U.S., while Canadian support program payments are positively related to weaner pig exports. Feeder cattle and calf trade, however, does not appear to have a relationship with U.S. support payments, while Canadian support payments have a negative relationship with feeder cattle and calf trade.

6. How do grain companies gain unfair advantage?

The most direct method crop subsidies can improve profit margins for US grain companies is the enhanced output increases throughput, and given the economies of scale in grain handling (especially with respect to market information economies major grain companies are known to have), this means more profits. Whether they keep these profits or use to cross subsidize in world markets is an empirical question.

However, there is evidence that grain companies have higher profit margins when purchasing grain under government programs for foreign food aid. Barrett (2002) reports that U.S. grain companies derive an extra 17 percent profit margin on food aid shipments compared to the profit margin of commercial sales. Presumably, they are not able to obtain a premium with the marketing loan or certificate loan program.

There is no real incentive for farmers not to try to get the maximum price for their product, regardless of the level of subsidies. Farmers are guaranteed the loan rate, no matter what. If farmers choose to declare the loan at times of the year such that market prices are lower that the annual average, than the gross price received by farmers is even greater than the guaranteed loan rate. This is because sales are not required at the time of making a loan. Westcott (1999) provides data for 1998 crop year where (1) farmers received an effective price well above the loan rate for three commodities whose market price was below the loan rate; and (2) other commodities received LDPs and EMLAs even though the average market price exceeded the loan rate. In addition to farmers being able to time their declarations versus actual sales in their favor, the reasons for these two phenomena may be that loan rates and the calculation of LDPs/EMLAs are differentiated by county such that the average market price for the United States is higher than the national loan rate, but that locally (in some counties) the market price is below the county loan rate. Furthermore, the loan rate may have been fixed too high in some counties compared to market prices that usually prevail or the posted county price (a proxy for the average market county price) may be too low (this latter case is shown for soybeans in a report by the GAO). The USDA, based on price quotations in particular terminal markets, computes the posted county price daily.

The impact of U.S. programs on the competitiveness on Canadian based grain handling firms and Canada's role in the international grain business is rather difficult to assess. Moreover, the linkage is not abundantly clear, especially in light of the fact that Canadian grain handling companies are tied (albeit indirectly) to the Canadian Wheat Board and tend to behave in an oligopolistic manner in the domestic market place (Wilson, 2005). That said, it is important to recognize an indirect linkage via the international market place. Specifically, Canada is viewed as a major player in the international grain market (largely through the Canadian Wheat Board). Consequently, if U.S. support programs affect the position of the residual demand curve Canadian exporters face, then the pricing strategies used by these exporters will be affected. For instance, if U.S support programs cause the residual demand curve Canadian exporters face to become more elastic, then any premia Canadian grains garner in the market place may be eroded.

7. Conclusions

This paper describes and analyzes the potential impacts of crop subsidies in indirectly subsidizing livestock production in the United States, and thereby affecting geographical production and trade patterns. We first evaluated the effects of U.S. crop programs on production and prices, using the parameters of the landmark WTO Panel ruling on the U.S. cotton sector (wheat and feed grain sectors have identical policies). We find the subsidy programs do have some significant impacts on production and prices. This impact may be tempered or offset by land taken out of production due to the CRP. However, if the net effect is for supplies to increase and prices reduced, U.S. livestock farmers gain an advantage, given the nature of U.S.-Canada price transmission. Our results also suggest that U.S. support programs have a bearing on Canadian farm incomes. Specifically, our calculations suggest that a one percent decrease in U.S. prices (due to U.S. support programs) can generate between a 1.3 and two percent reduction in grain and oilseed farm income in Canada. Given this, one might expect the adverse effect of anticipated record U.S. support program payments in 2005 (see Figure 1) to have a significantly negative effect on Canada's grain and oilseed sector farm incomes in 2005. However, the CRP may well offset any supply increasing effects of U.S. subsidies – such an effect may well temper any corresponding farm income effects in Canada.

We also showed that a significant amount of crop production would occur below the costs of production if farmers were to receive market prices only. Evaluating U.S. crop production data over the long term showed no change in the trend after the so-called "decoupling" episodes. But having said that, we think forces much larger than U.S. subsidy programs are impacting world trade and prices. U.S. export growth rates have been lower than world export growth rates in these crops while that of Canada and emerging countries like Brazil and Argentina have been remarkable (Figure 14). Within that context, Canada's export growth has been substantial, with exchange rate movements being a large factor. In absolute terms, U.S. exports have only increased in soybeans in the past 25 years (with average exports declining substantially in other crops) while exports in all crops from Argentina and Brazil have increased substantially (see Figure 15).

We show how U.S. production can be cross-subsidized with crop subsidies by covering fixed costs of production and allowing the farmer to remain in business, expand beyond the base, and induce more farmers to enter production. Coupled subsidies are more output distorting in the absence of an exit option, but decoupled subsidies are nevertheless more effective in deterring exit for a given gross transfer to farmers because economic inefficiency due to "coupling" do not arise. We also evaluate the possibility of intra-firm cross-subsidization where livestock and crop production occurs on the same farm. With economies of scope, this can occur, just as in the case of a single product crop farmer. However, data suggest it is probably of minimal importance for hogs, given the degree of specialization and integration in the U.S. hog industry. It is an empirical question as to how important it is for beef cattle production. An empirical study for crops alone does suggest significant cross-subsidization can occur.

We analyze several factors that affect the location of livestock production in Canada, including policies on both sides of the border. In addition, we try to explain trade flows of feeder cattle and weaner pigs using regression analysis. Our findings suggest relative grain subsidies in Canada have an economically significant bearing on Canadian feeder cattle and calf exports, and that both Canadian and U.S. support payments have a bearing on Canadian weaner pig exports. More subsidies in Canada decrease exports of feeder cattle and calves, while weaner pig exports decrease with U.S. support payments, but increase with Canadian support payments.

The impact of U.S. programs on the competitiveness on Canadian based grain handling firms and Canada's role in the international grain business is rather difficult to assess. There are some instances where U.S. grain companies can benefit from U.S. crop subsidies but enhanced production in the United States may reduce the ability for the Canadian Wheat Board to price discriminate, thereby reducing the pooled prices to Canadian crop farmers.

The unanswered question is whether cross-subsidization affects the geographic location of livestock production. To this end, note that U.S. subsidies were shown to lower the price of feed grains in the U.S. As these crops tend to be better suited to particular regions of the U.S., it stands to reason that we will observe increased scale and concentration of livestock feeding in the U.S. corn-belt, western great lake and Great Plains regions, and perhaps the U.S. southeast. The adage that livestock follows grain production seems to hold true. Moreover, the livestock processing sector will follow production and, once in place, processing will tend to remain in place in the intermediate run.

U.S.-Canada price transmission elasticities would suggest that feed prices in eastern Canada would fall by a greater percent than in western Canada. In principle this lends itself to expanded livestock feeding in the east. However, institutional features, such as the Nutrient Management Act in Ontario and issues related to hog subsidies in Quebec, may forestall efforts to expand animal feeding. Moreover, a small land base and rising land prices in southern Ontario and other densely populated areas of eastern Canada do not lend themselves to expanded livestock feeding in eastern Canada. At the same time, feed grain price changes in western Canada may be such that this region may lose some advantage it held with respect to animal feeding. In this case, one could envisage Canada specializing in production of feeder animals which are exported to the U.S. for finishing. Such an outcome would be dependant on resolution of trade actions taken by the U.S. vis-à-vis live cattle trade with Canada and, to a limited degree, countervailing duties on hogs. Given the extent of vertical integration in the North American meat industry (prior to BSE in North America), such an outcome is not inconceivable.

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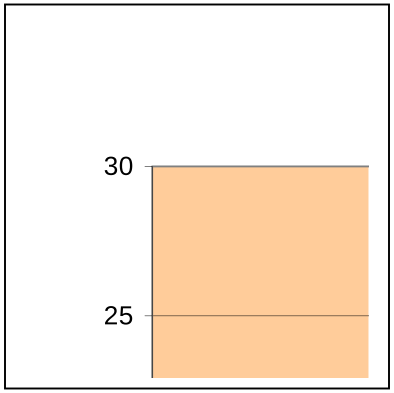


Source: USDA http://www.ers.usda.gov/Briefing/FarmIncome/data/gp_t7.htm

Figure 2: U.S. Acres Diverted vs. in CRP (wheat, feedgrains & soybeans)

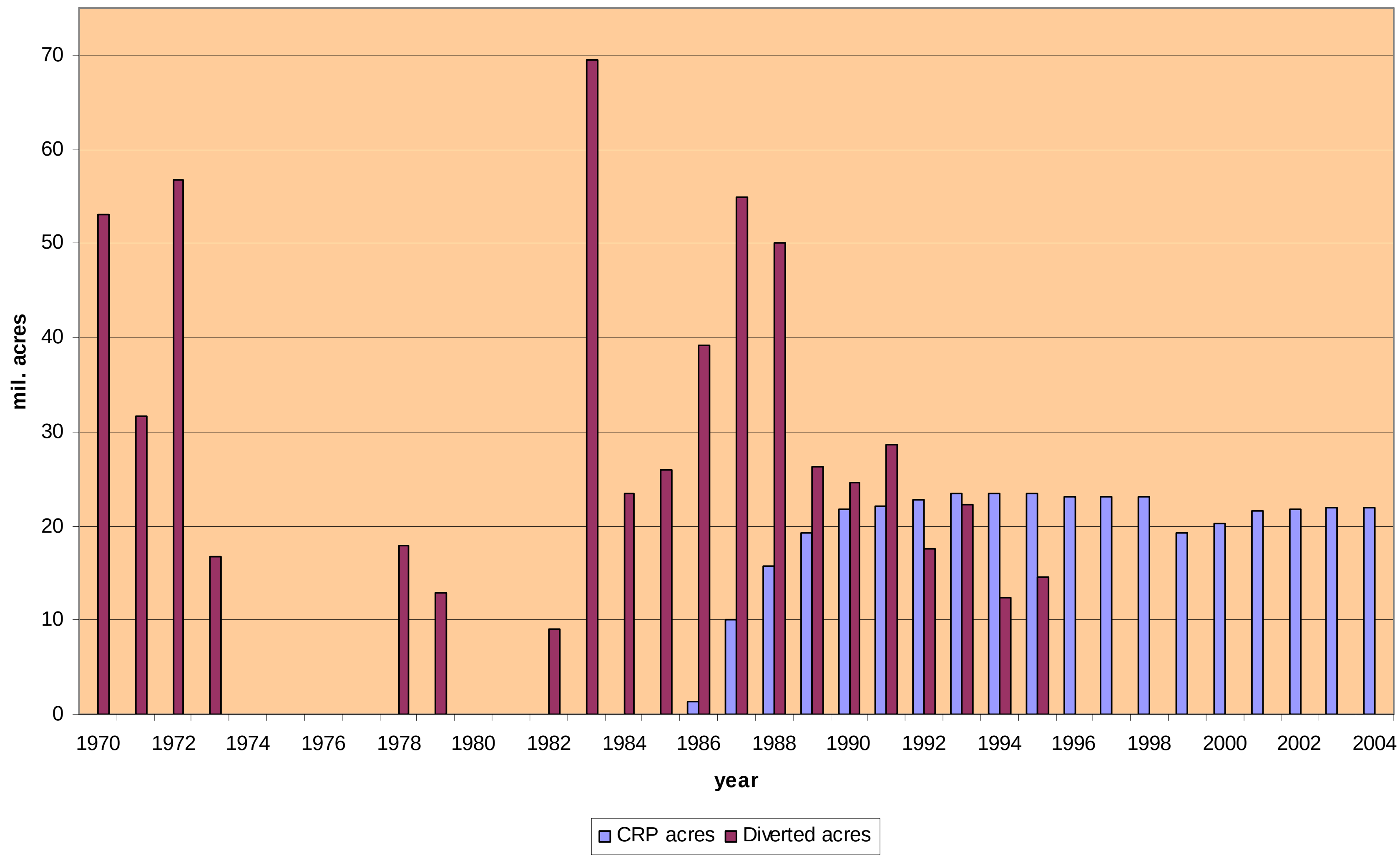


Figure 3: U.S. CRP + Diverted as % of Total Acres Planted

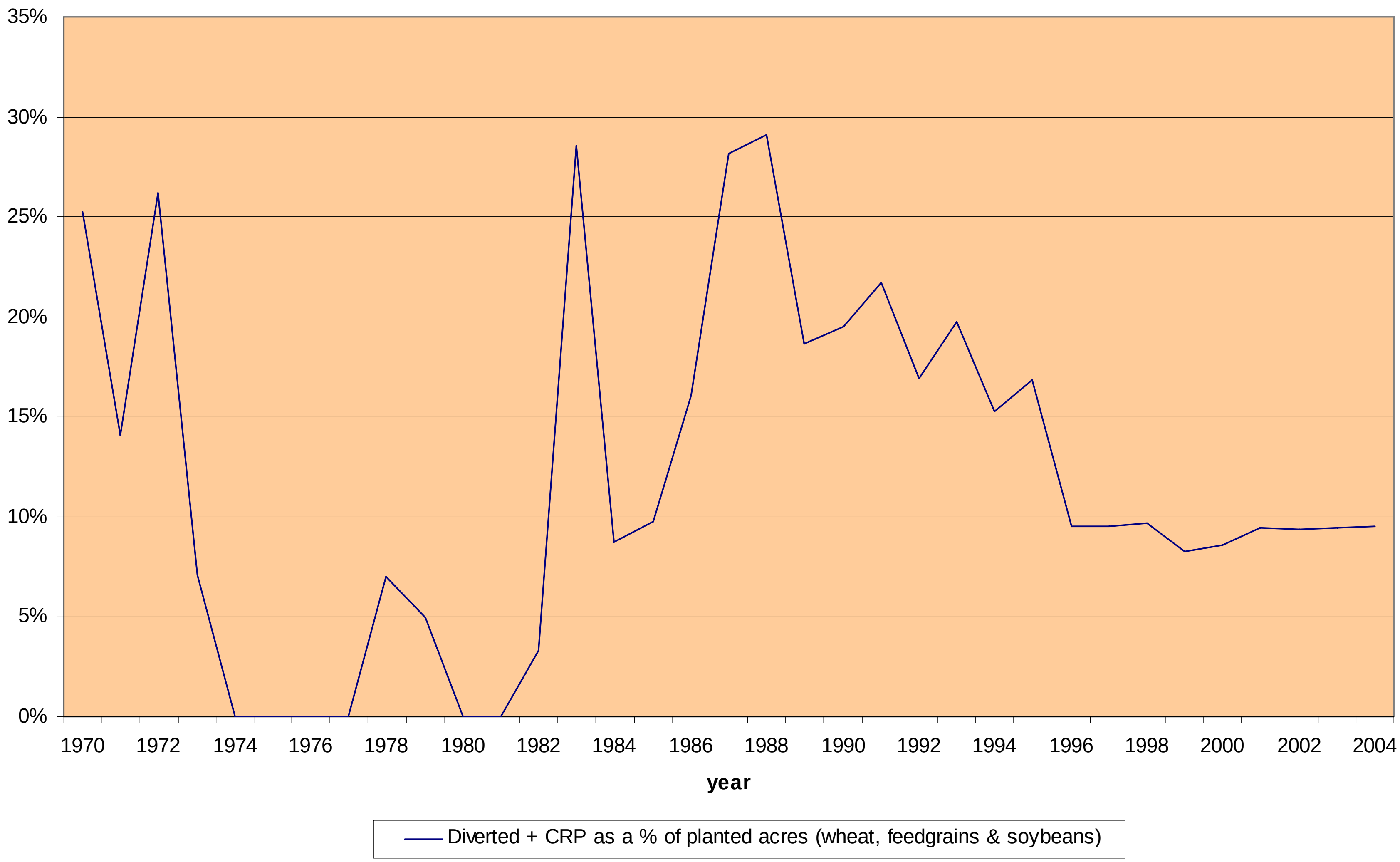


Figure 4: U.S. Feedgrains Production

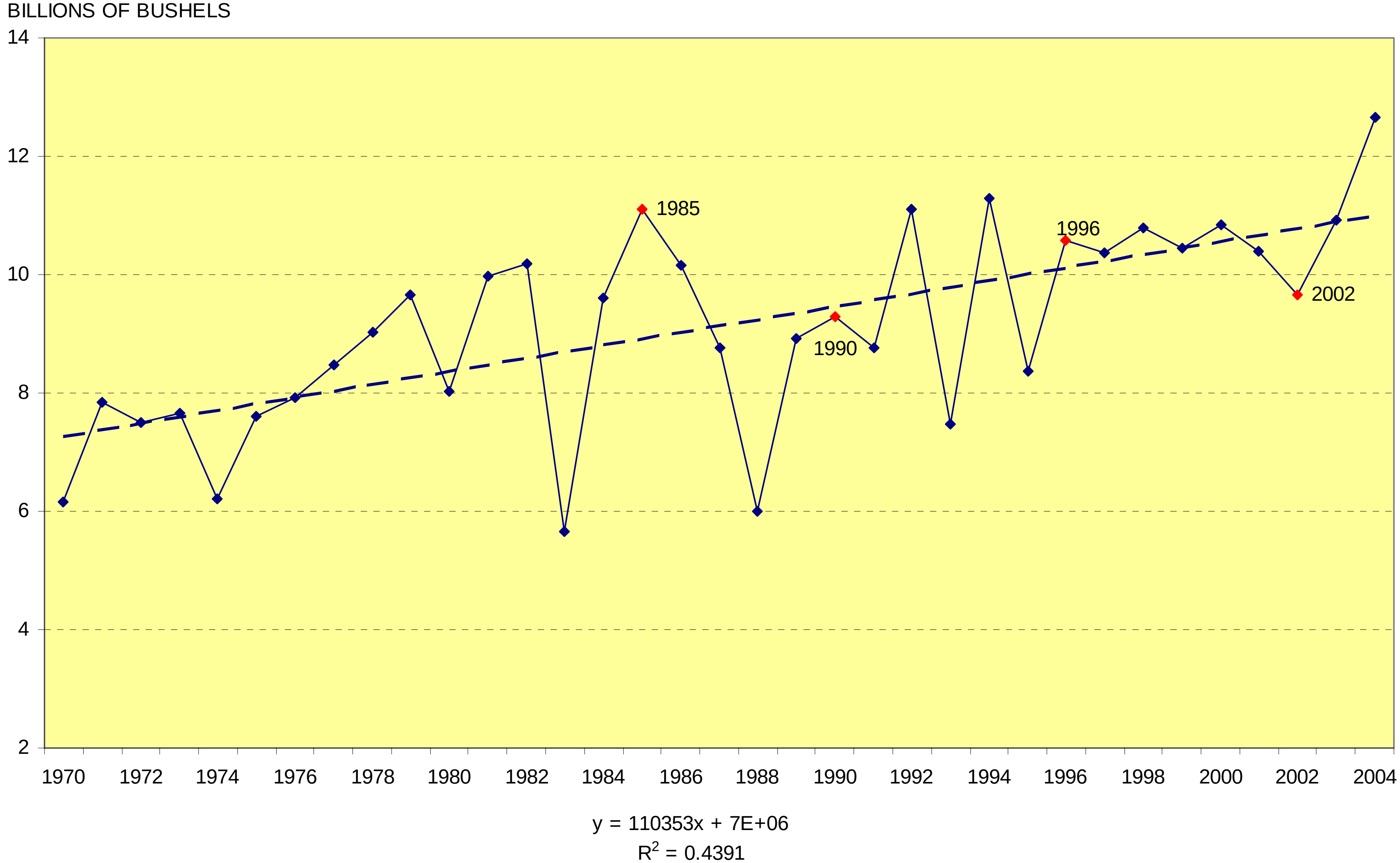


Figure 5: U.S. Soybean Production

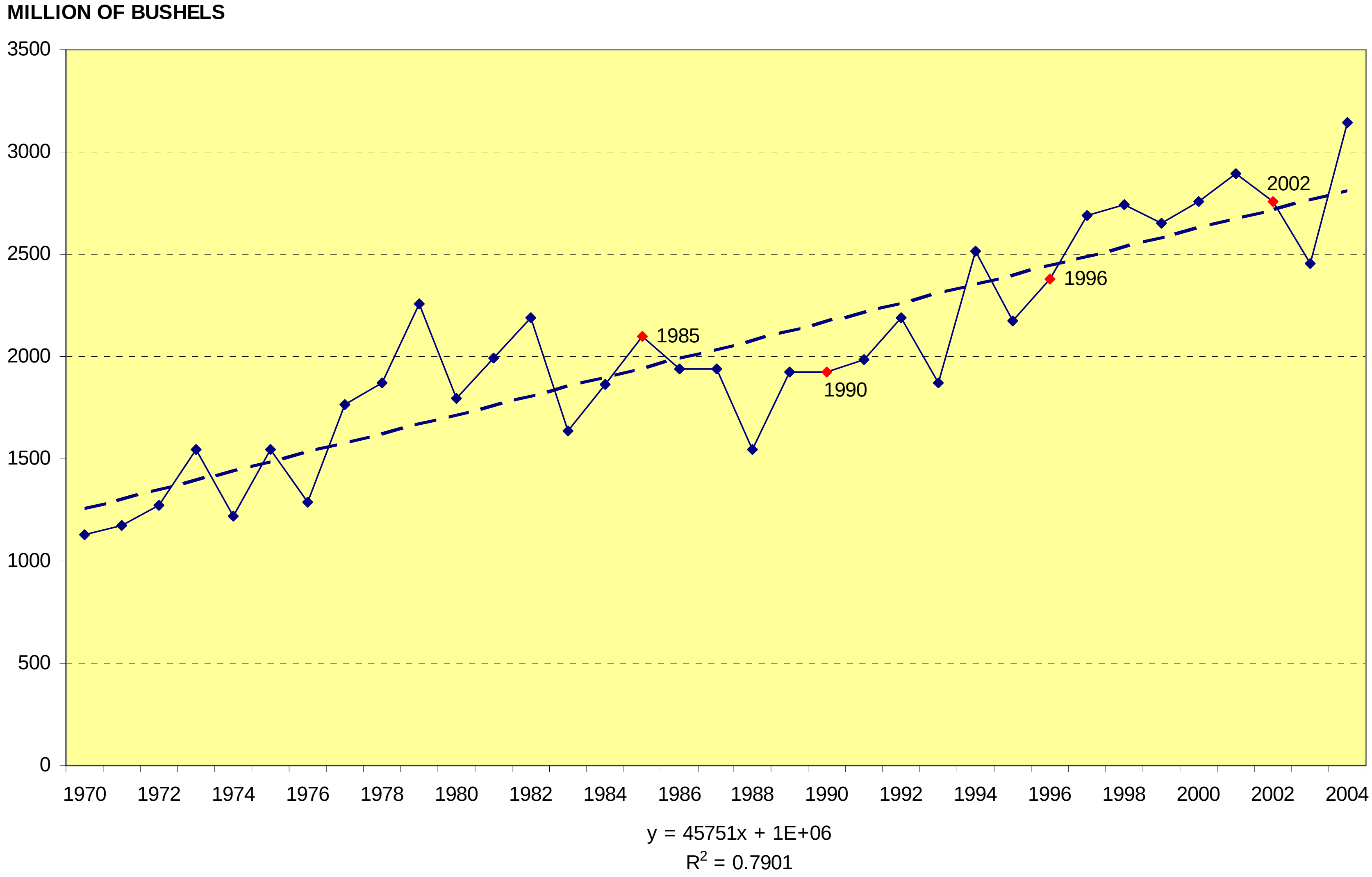


Figure 6: Wheat Production in Canada

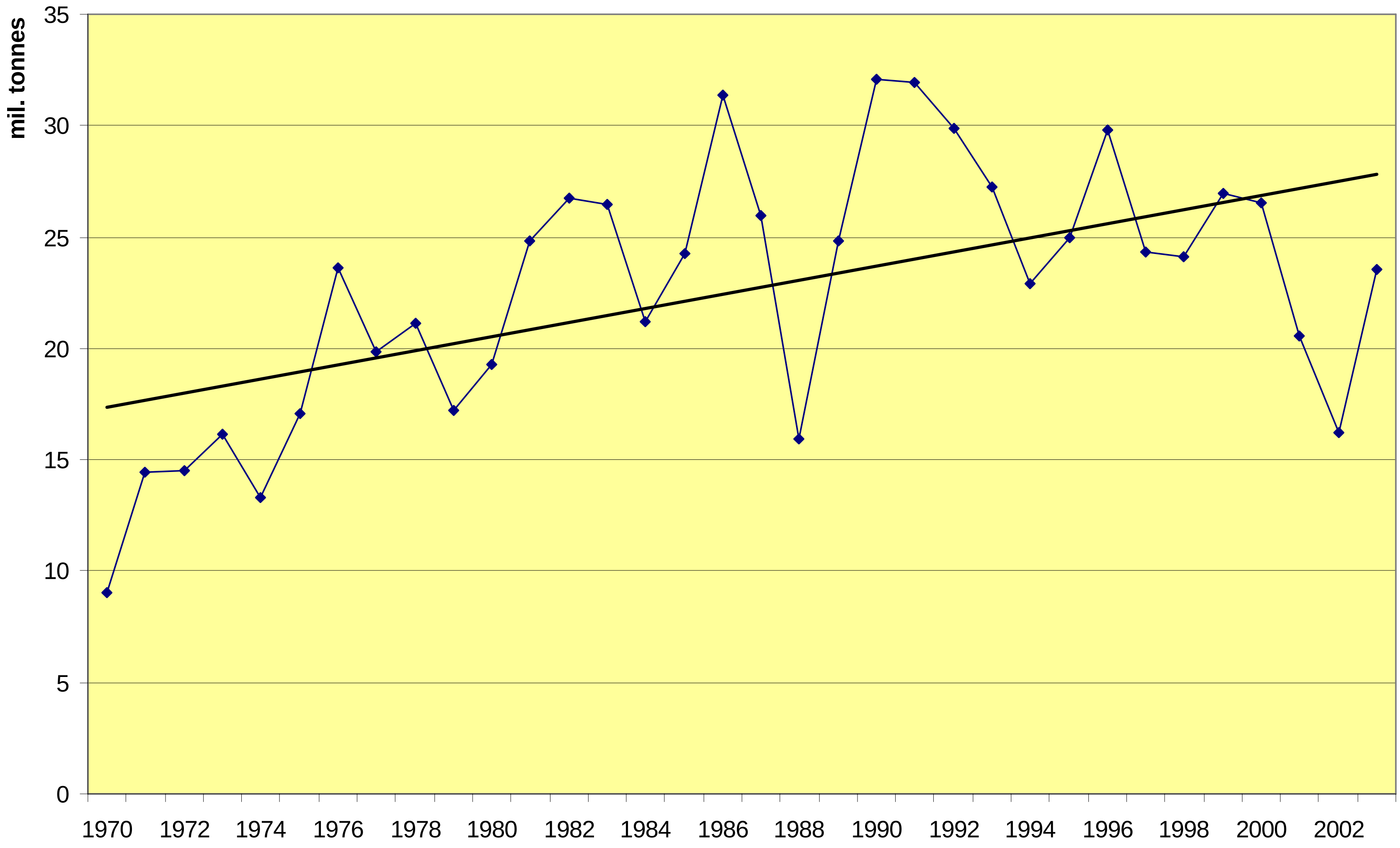


Figure 7: Feedgrain Production in Canada

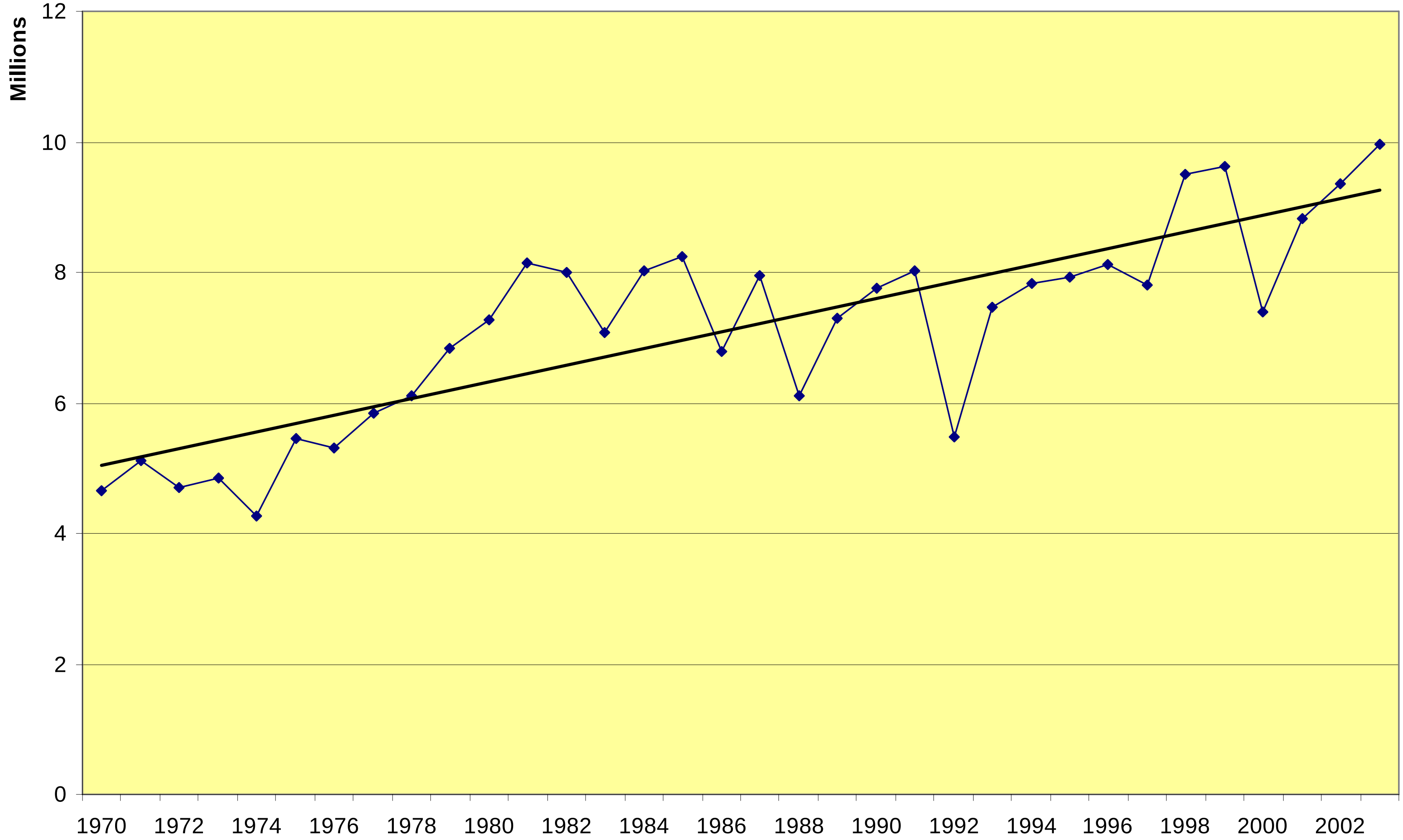


Figure 8: US PROTEIN CROP PRODUCTION

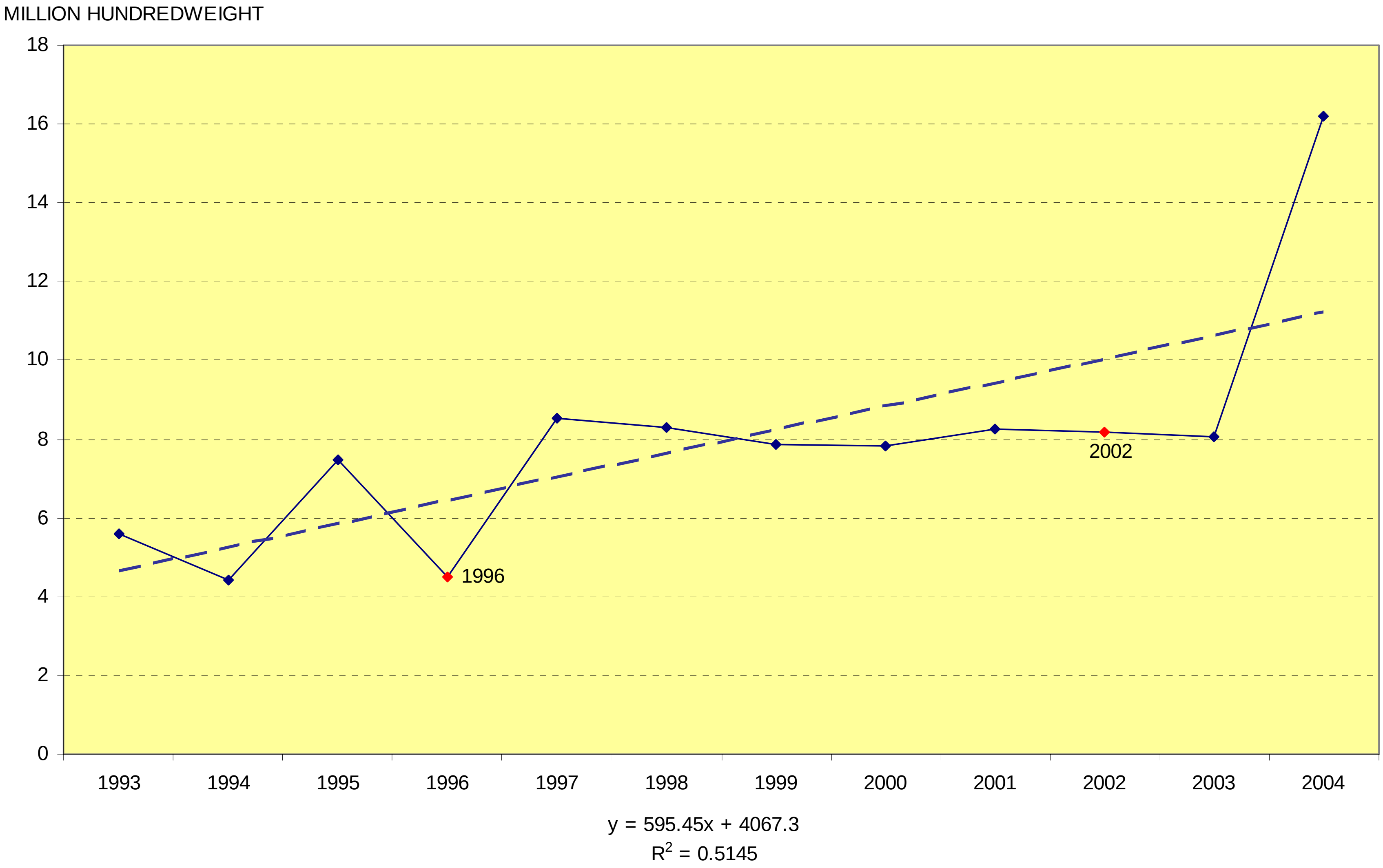


Figure 9: U.S. Domestic Support for Wheat

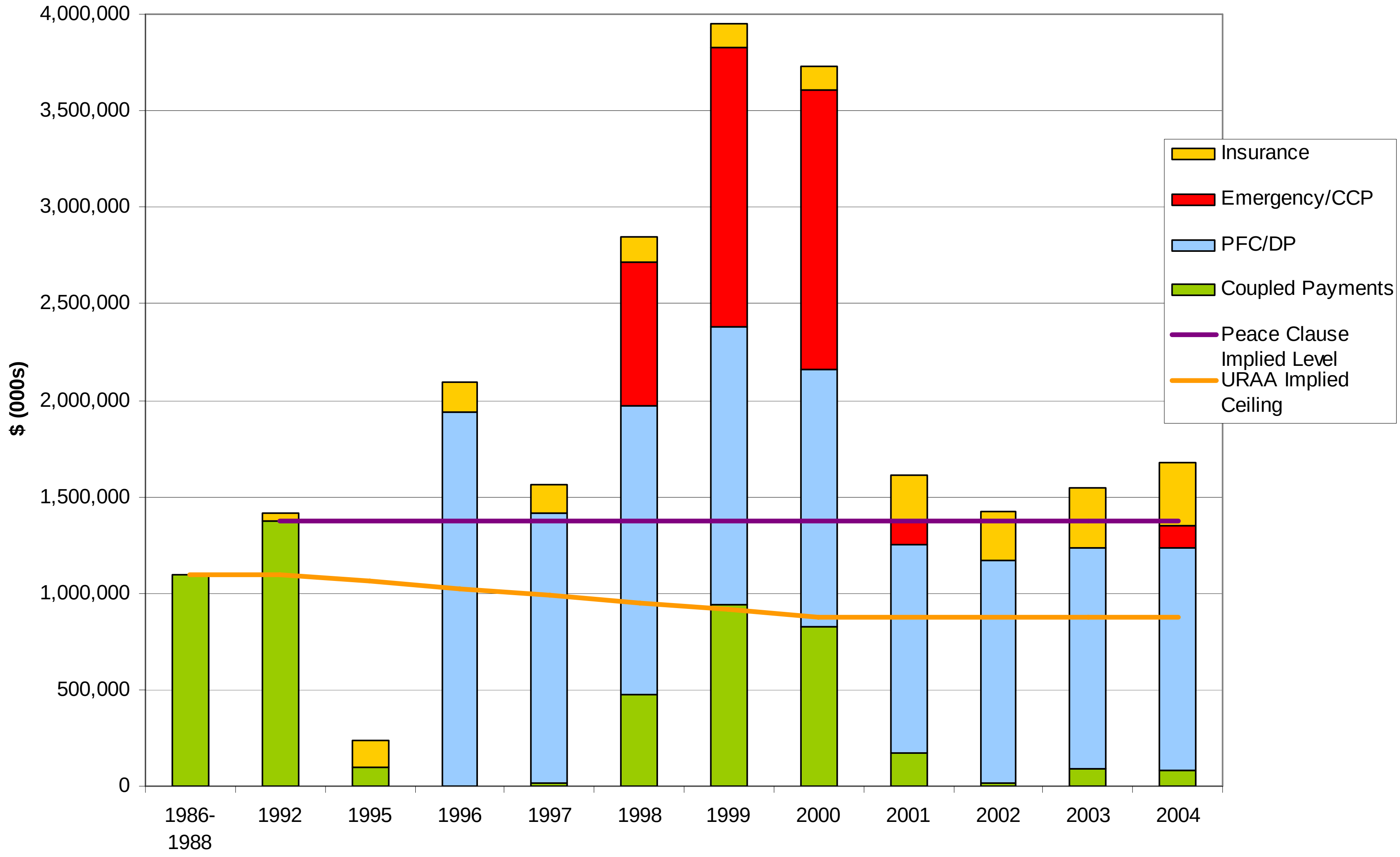


Figure 10: Corn Domestic Support

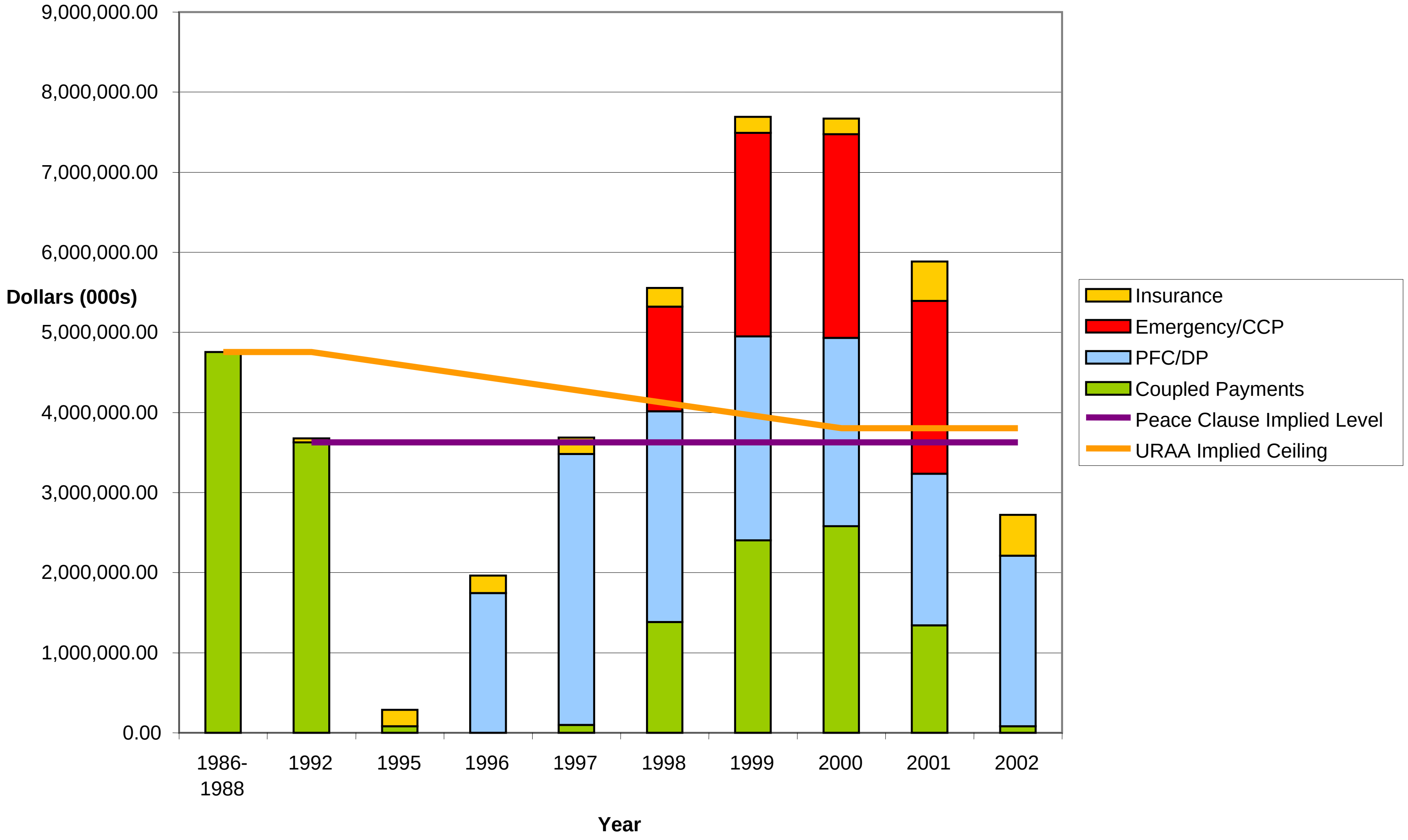


Figure 11: Cumulative Distribution of Production Costs for Corn: Number of Farms and Level of Production (United States 2001)

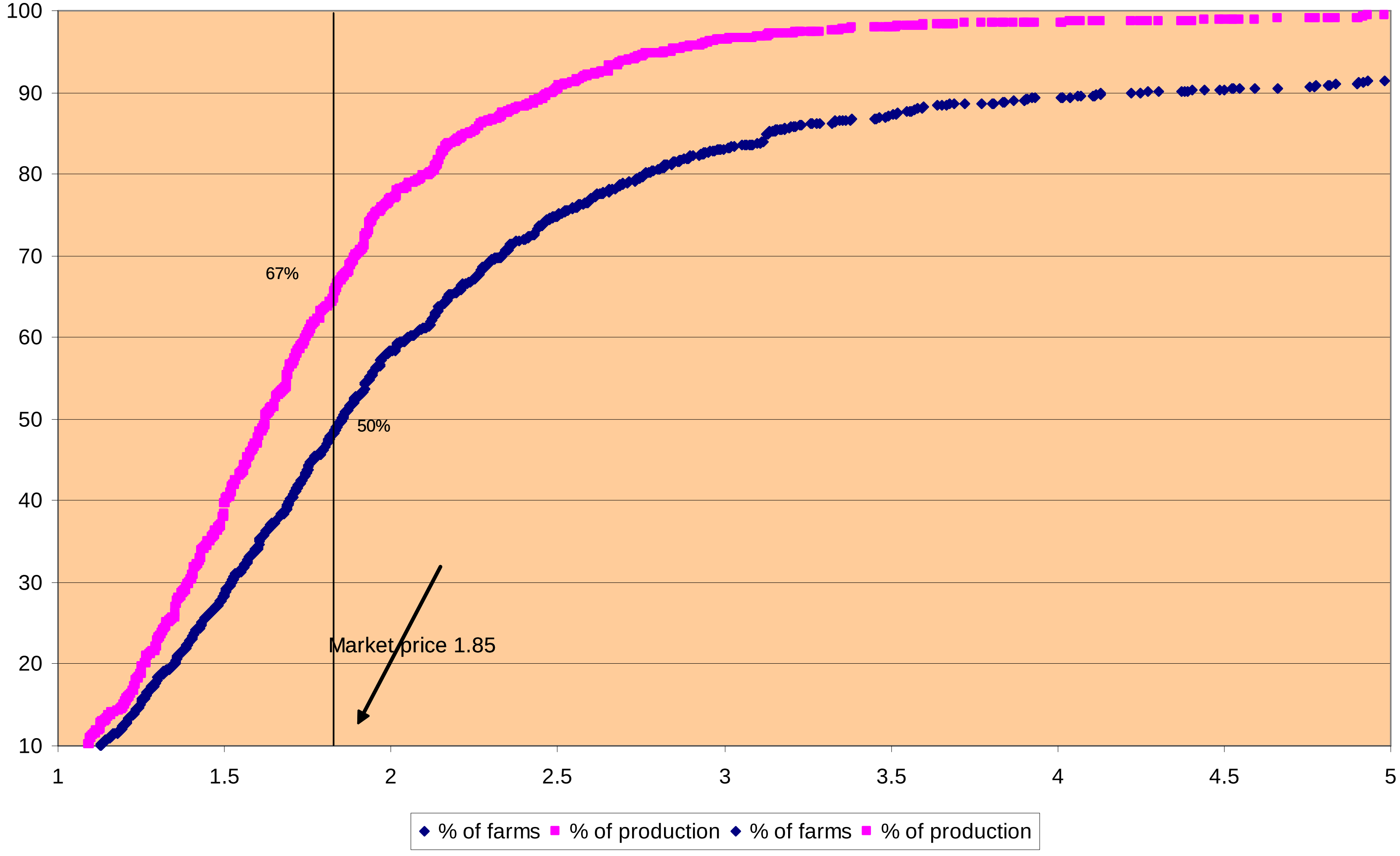
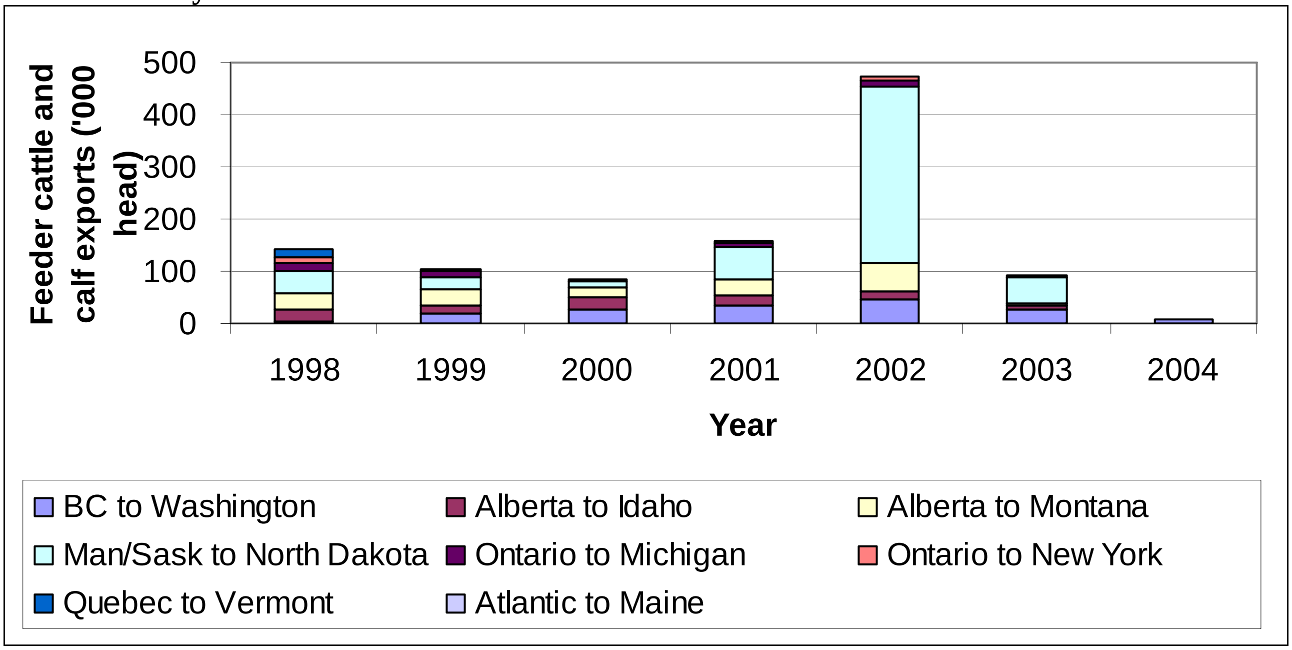
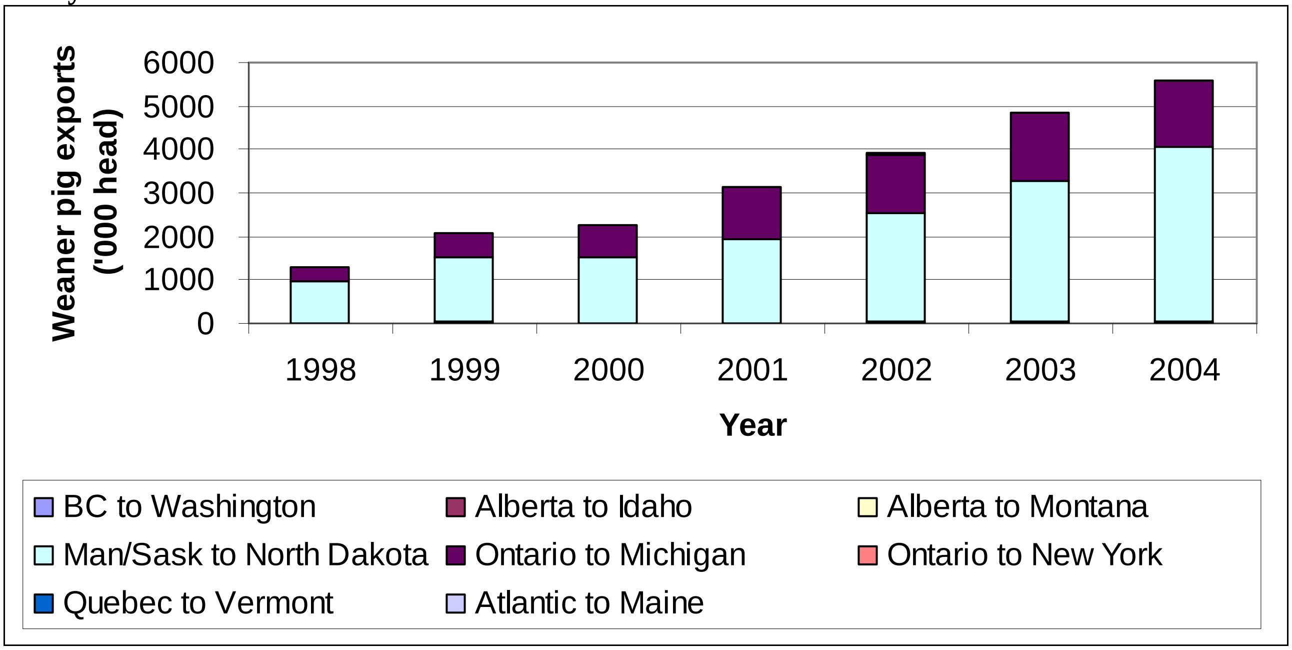


Figure 12: Feeder Cattle and Calf Exports from Canadian Provinces to the U.S., via U.S. States of Entry



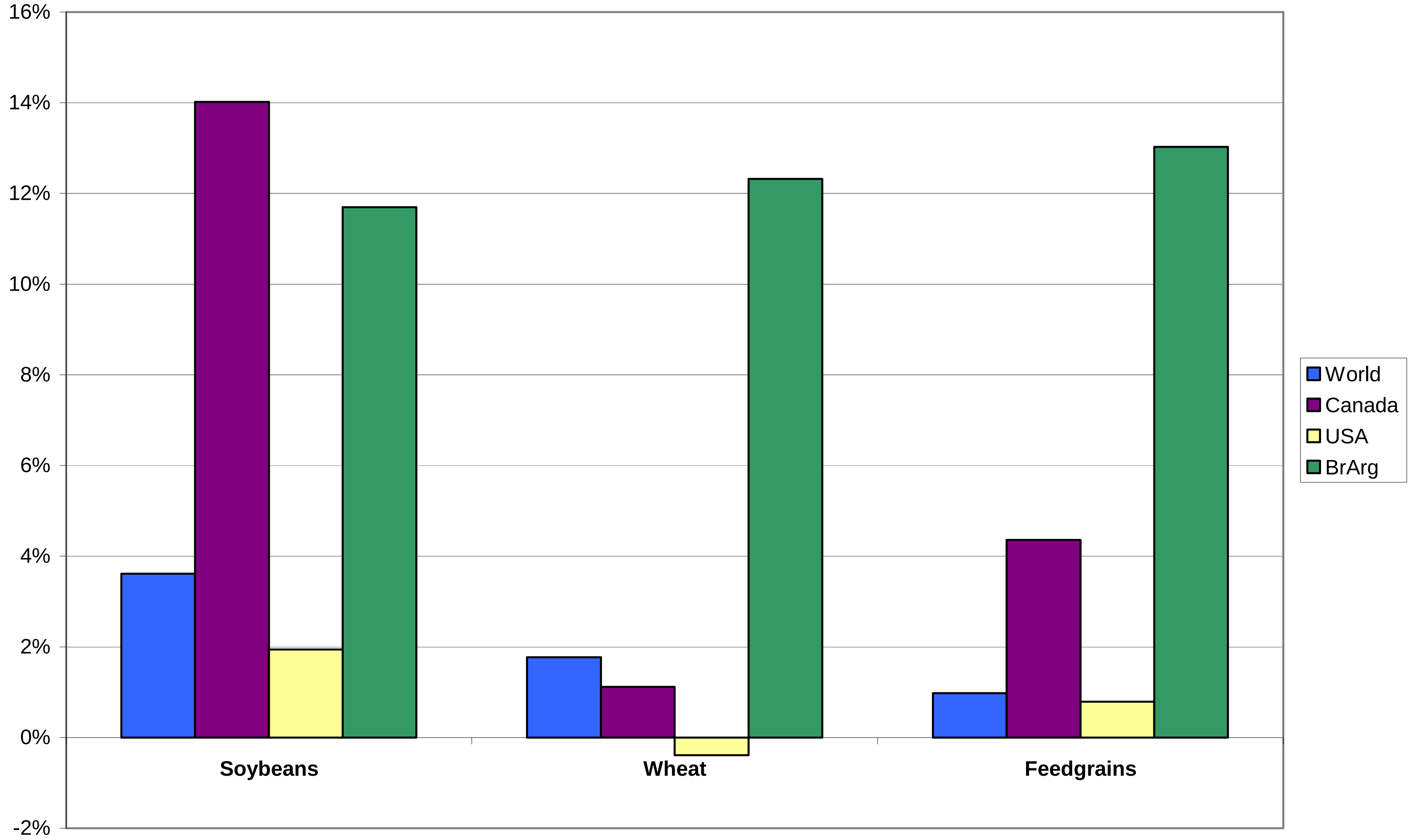
Source: Agriculture and Agri-Food Canada, Red Meats Unit

Figure 13: Weaner Pig Exports from Canadian Provinces to the U.S., via U.S. States of Entry



Source: Agriculture and Agri-Food Canada, Red Meats Unit

Figure 14: Export Growth Rates 1980-2002



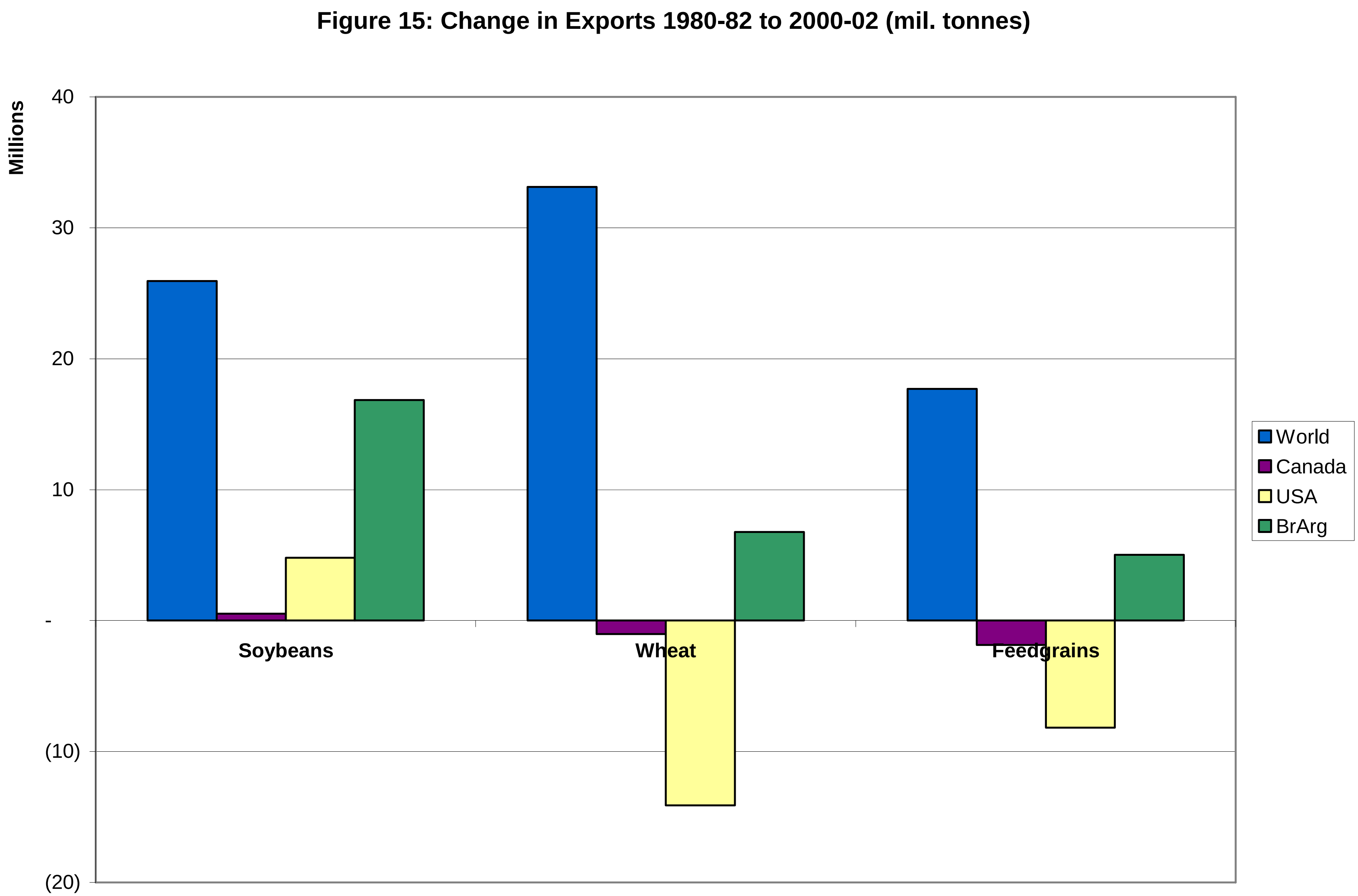


Figure 15: Change in Exports 1980-82 to 2000-02 (mil. tonnes)
Millions
40
30
20
10
-
(10)
(20)
Soybeans
Wheat
Feedgrains
World
Canada
USA
BrArg

Table 1A: Average Prices, Production and Subsidies 2000-2001 (US Major Field Crops)

	Price	Production	Government Subsidies								
	$/bu	'000 bu	Total	Direct		Countercyclical		Deficiency		Crop Insurance	
			$/bu	'000 $	$/bu	'000 $	$/bu	'000 $	$/bu	'000 $	$/bu
Wheat											
2000	2.48	2,299,010	1.62	1,337,127	0.58	1,444,444	0.628	824,477	0.359	120,182	0.052
2001	2.62	2,232,460	0.72	1,076,061	0.48	122,370	0.055	175,799	0.079	239,137	0.107
2000-01	*2.55*	*2,265,735*	*1.17*	*1,206,594*	*0.53*	*783,407*	*0.342*	500,138	*0.219*	*179,660*	*0.080*
Feedgrains											
2000	1.85	10,853,000	0.79	2,721,070	0.25	2,942,764	0	2,663,733	0	222,651	0.02
2001	1.97	10,383,000	0.62	2,197,746	0.21	2,496,519	0	1,213,311	0	552,574	0.05
2000-01	*1.91*	*10,618,000*	*0.71*	*2,459,408*	*0.23*	*2,719,642*	*0*	*1,938,522*	*0*	*387,612*	*0.04*
Soybeans											
2000	4.54	2,757,800	0.98	0	0	154,626	0.06	2,534,858	0.92	0	0
2001	4.38	2,890,700	1.30	0	0	294,856	0.10	3,476,805	1.20	0	0
2000-01	*4.46*	*2,824,250*	*1.14*	*0*	*0*	*224,741*	*0.08*	*3,005,832*	*1.06*	*0*	*0*

Source: USDA

Table 1B: Average Prices, Production and Subsidies 2003-2004 (US Major Field Crops)

	Price	Production	Government Subsidies								
	$/bu	'000 bu	Total	Direct		Countercyclical		Deficiency		Crop Insurance	
			$/bu	'000 $	$/bu	'000 $	$/bu	'000 $	$/bu	'000 $	$/bu
Wheat											
2003	3.40	2,345,000	0.66	1,142,573	0.49	0	0.00	93,344	0.04	311,161	0.13
2004	3.48	2,158,000	0.78	1,149,724	0.53	115,677	0.05	82,698	0.04	325,137	0.15
2003-04	*3.44*	*2,251,500*	0.72	*1,146,149*	*0.51*	*57,839*	*0.03*	*88,021*	*0.04*	*318,149*	*0.14*
Feedgrains											
2003	2.45	10,922,000	0.28	2,393,000	0.22	0	0.00	94,000	0.01	620,587	0.06
2004	2.21	12,657,000	0.69	2,406,000	0.19	3,597,000	0.28	1,949,000	0.15	795,650	0.06
2003-04	*2.33*	*11,789,500*	0.49	*2,399,500*	*0.20*	*1,798,500*	*0.14*	*1,021,500*	*0.08*	*708,119*	*0.06*
Soybeans											
2003	7.25	2,454,000	0.37	602,000	0.25	0	0.00	0	0.00	294,860	0.12
2004	6.10	3,141,000	0.62	601,000	0.19	551,000	0.18	520,000	0.17	283,723	0.09
2003-04	*6.68*	*2,797,500*	0.49	*601,500*	*0.22*	*275,500*	*0.09*	*260,000*	*0.08*	*289,292*	*0.11*

Source: USDA

Table 2A: Effect of U.S. Subsidies on Production and Prices (2000-2001 average)

	% change in production				
	All subsidies	**Direct**	**Counter-cyclical**	**Deficiency**	**Crop Insurance**
Wheat	3.18%	0.7%	0.8%	1.2%	0.4%
Feedgrains	2.83%	0.43%	0.77%	1.35%	0.28%
Soybeans	3.50%	0%	0.10%	3.40%	0%
	% change in price				
	All subsidies	**Direct**	**Counter-cyclical**	**Deficiency**	**Crop Insurance**
Wheat	-6.4%	-1.49%	-1.53%	-2.45%	-0.89%
Feedgrains	-5.7%	-0.86%	-1.53%	-2.71%	-0.55%
Soybeans	-7.0%	0%	-0.20%	-6.80%	0%

Source: calculated by authors using formulas developed in Gardner (1987), pages 30-33.

Table 2B: Effect of U.S. Subsidies on Production and Prices (2003-2004 average)

	% change in production				
	All subsidies	Direct	Counter-cyclical	Deficiency	Crop Insurance
Wheat	1.32%	0.53%	0.04%	0.16%	0.59%
Feedgrains	1.53%	0.31%	0.35%	0.50%	0.37%
Soybeans	0.59%	0%	0%	0.18%	0.23%
	% change in price				
	All subsidies	**Direct**	**Counter-cyclical**	**Deficiency**	**Crop Insurance**
Wheat	-2.6%	-1.06%	-0.09%	-0.32%	-1.18%
Feedgrains	-3.1%	-0.63%	-0.70%	-1.00%	-0.73%
Soybeans	-1.2%	-0.23%	-0.15%	-0.35%	-0.45%

Source: calculated by authors using formulas developed in Gardner (1987), pages 30-33.

Table 3: U.S. Dumping Margins with # of Farms and Levels of Production Below Market Prices (2001)

	Market Price ($/bu)	Costs of Production ($/bu)		Dumping margin over		Cumulative Distribution of Production Costs	
		Total	Operating	Total costs	Operating costs	% of farmers below market price	% of production below market prices
Wheat	2.76	5.58	3.60	102.2%	30.4%	59.2%	69.3%
Soybeans	4.15	6.77	3.71	63.1%	0%	69.3%	81.2%
Corn	1.85	2.76	1.75	49.1%	0%	49.8%	67.0%

* Operating costs include costs of insurance, taxes and depreciation.
Source: Cumulative distribution of costs of production furnished by the USDA upon request (documentation: http://www.ers.usda.gov/Data/CostsAndReturns/)
Market prices are for 2001. Costs of production for corn (1996), wheat (1998) and soybeans (1997) - available only for one year.

Table 4: Costs of Production, Market Revenue and Government Subsidies for Major Crops in the United States 1/

	Wheat		Corn		Soybeans	
	2002	2003	2002	2003	2002	2003
Total Costs of Production	175.63	191.41	329.54	349.78	232	238.49
Operating (Variable) Costs	57.07	67.79	140.71	156.53	73.5	77.66
Allocated Overhead - Fixed Costs	118.56	123.62	188.83	193.25	158.5	160.83
Market Revenue	94.8	128.4	263.7	310.6	206.0	245.4
Market Revenue less total costs (excl. unpaid labor)	-64.1	-45.8	-40.1	-12.6	-10.5	23.0
Total government subsidies 2/	19.7	18.0	37.5	18.0	46.6	12.4
Revenue plus subsidies less total costs (excl. unpaid labor)	-44.4	-27.8	-2.6	5.4	36.1	35.4

1/ All data on a per acre planted basis.
2/ Total government payments include DPs, CCPs, LDPs, crop insurance and other direct subsidies
Source: USDA costs are from http://www.ers.usda.gov/Data/CostsAndReturns/
Production, acres and prices from http://www.ers.usda.gov/publications/agoutlook/aotables/2005/mar/aotab17.xls
Government subsidies from http://www.fsa.usda.gov/dam/bud/CCC%20Estimates%20Book/estimatesbook.htm

Table 5: Fixed Costs and Subsidies on U.S. Beef and Hog Farms

	Beef cattle	Hogs
Number of farms	736,600	18,747
Value of production per farm	53,543	573,151
Gross cash income per farm	44,989	370,549
Livestock income	34,060	270,101
Crop sales	2,772	41,926
Government payments	2,036	7,393
Costs of production per farm		
Variable	31,170	251,691
labor	2,483	32,060
Fixed	8,240	38,330
Depreciation	4,748	26,007
Labor non-cash	207	317
Variable costs net of labor	28,687	219,631
Fixed costs net of labor	15,678	96,714
Value of production industry	39,439,773,800	10,744,861,797
Costs of production industry		
Variable	21,130,844,200	4,117,422,357
Fixed	11,548,414,800	1,813,097,358
Total	32,679,259,000	5,930,519,715
Fixed cost share	35.3%	30.6%
Government payments	1,499,717,600	138,596,571
as share of fixed costs	13.0%	7.6%
as share of total revenues	3.8%	1.3%

Source: special USDA run on ARMS (Agricultural Research Management Survey) databank.
Note: Data is for the year 2003.

Table 6: descriptive statistics of feeder animal trade model variables

Variable	MEAN	ST. DEV	MINIMUM	MAXIMUM
Feeder cattle and calf exports from Canada to the U.S. (head)	19103	46411	0	340200
Weaner pig exports from Canada to the U.S. (head)	413430	865070	0	4009200
Dollar value of U.S. support programs (US$’000)	14589000	4977000	7124900	21175000
Dollar value of Canadian support programs ($’000)	2738700	1205100	881880	4237100
Ratio of the price of feeder cattle in western Canada to barley price in Canada	80.777	17.673	61.077	109.66
Ratio of the price of weaner pigs in Canada to barley price in Canada	53.168	18.301	37.555	86.260
Ratio of the price of feeder cattle in the U.S. to corn price in the U.S.	44.339	3.520	39.216	50.195
Ratio of the price of weaner pigs in the U.S. to corn price in the U.S.	45.618	9.230	30.567	60.541
CND-US exchange rate. (CND$/US$, in hundreds)	146.78	8.5504	130.11	157.02

Table 7: support variable description and sources

Variable	Definition	Source
Feeder cattle and calf exports from Canada to the U.S.	Head of feeder cattle and calves exported	AAFC, Red Meat Annual Report
Weaner pig exports from Canada to the U.S.	Head of weaner pigs exported	AAFC, Red Meat Annual Report
Dollar value of U.S. support programs	Sum of expenditure on: • production flexibility contracts, • fixed direct payments • counter-cyclical payments • loan deficiency payments • marketing loan gains • Ad Hoc and emergency payments • Miscellaneous programs	USDA, ERS, Farm Income Data, Government Payments, United States by program 1996-2003; and USDA, ERS, Briefing Room, Farm Income and Costs: Farm Income Forecasts
Dollar value of Canadian support programs	Sum of net expenditure on: • Gross Income Revenue Program • Net Income Stabilization Account • Western Grain Stabilization • Income Disaster Assistance Programs • Provincial Stabilization Programs • Tripartite Payments • Crop Insurance • Other	Statistics Canada, "Direct Payments to Agricultural Producers", Nov 2004, and the Ontario Ministry of Agriculture and Food.
Price of feeder cattle in western Canada	Price of 800-901 lbs feeder steers in Alberta ($ CWT)	AAFC, Red Meat Annual Report
Price of weaner pigs in Canada	Price of 40-50 lbs feeder hogs in Ontario ($ CWT)	AAFC, Red Meat Annual Report
Price of barley in Canada	Average price ($/tonne)	AAFC, Market Analysis division
Price of feeder cattle in the U.S.	Price of 600-700 lbs feeder steers in Oklahoma City (US$ CWT)	AAFC, Red Meat Annual Report
Price of weaner pigs in the U.S.	Annual average prices paid, feeder pigs, United States (US$ CWT)	USDA, NASS, Agricultural Prices
Price of corn in the U.S.	Average price ($/bu)	USDA, NASS
CND-US exchange rate.	CND$/US$	Bank of Canada

Table 8: Regression results from feeder animal trade flow models

	Feeder cattle and calf		Weaner pig	
	Parameter estimates and t-statistics (in parenthesis)	Elasticities (evaluated at the means of the data)	Parameter estimates and t-statistics (in parenthesis)	Elasticities (evaluated at the means of the data)
CONSTANT	-452240 (-6.173)		396160* (1.836)	
Value of U.S. support	-0.001 (-0.833)	-0.498	-0.008*** (-4.824)	-0.266
Value of Canadian support	-0.005** (-2.044)	-0.709	0.097*** (8.570)	0.640
Price of feeder animals in Canada divided by the price of barley in Canada	-1539*** (-3.025)	-6.509	-4718*** (-7.132)	-0.607
Price of feeder animals in the U.S. divided by the price of corn in the U.S.	5052*** (3.644)	11.727	9763*** (5.910)	1.077
CND-US Exchange rate	2716*** (7.458)	20.869	-5059*** (-4.947)	-1.796
AB_ID[A]	-7435 (-1.298)	-0.049	-4359 (-0.174)	-0.001
AB_MO	1511 (0.247)	0.010	3734 (0.234)	0.001
MS_ND	51856 (1.366)	0.339	2424200 (1.517)	0.733
ON_MI	-15082*** (-2.605)	-0.099	993810*** (3.193)	0.301
ON_NY	-19219*** (-3.450)	-0.126	3422 (0.295)	0.001
QU_VT	-20208*** (-2.891)	-0.132	-7906 (-0.888)	-0.002
AT_MA	-22948*** (-4.361)	-0.150	-7858 (-0.718)	-0.002
R-square	0.383		0.439	

A. *The fixed effects are denoted as follows: AB_ID represents Alberta-Idaho, AB_MO represents Alberta-Montana, MS_ND represents Manitoba/Sask-North Dakota, ON_MI represents Ontario-Michigan, ON_NY represents Ontario-New York, QU_VT represents Quebec_Vermont, AT_MA represents Atlantic-Vermont. The omitted variable represents BC-Washington state.*

B. **** denotes significant at the one percent level, ** denotes significance at the five percent level, * denotes significance at the ten percent level*

Appendix 1: The Analytics of Cross Subsidization

Direct income payments (not related to production) can cross-subsidizes in two ways: offset fixed costs (that are often a significant proportion of total costs in agriculture) and allow for economies of scale by allowing infra-marginal payments to cross subsidies marginal production at lower prices.[20] Offsetting fixed costs can deter exit or induce entry into crop production. DPs and CCPs are infra-marginal subsidies with the latter conditional on prices. In order to receive these payments, farmers are required to keep the land in "agricultural uses". Thus, it is an incentive to prevent some land from being converted to non-agricultural uses. Second, one can only obtain subsidies if you are a bona fide farmers (and are not allowed to get direct payments if they plant fruit and vegetable crops on their historical base area).

Chau and de Gorter identify the impacts of taxpayer and consumer financed infra-marginal production subsidies to farmers through the effects on farmers' ability to cover fixed and/or variable costs. Coupled support can be financed from either taxpayers or consumers, or a combination as in the case of export subsidies. Decoupled support can come in the form of infra-marginal production subsidies financed either by consumers (e.g., U.S. dairy countercyclical payments) or taxpayers (U.S. crop subsidies).[21] In this light, Chau and de Gorter identify production related factors that impact the magnitude of necessary transfers and prioritize various means of subsidy finance, such as consumer financed subsidies via trade measures, or taxpayer financed subsidies via direct payments. A framework isolating the production response of income transfers depending on whether it is taxpayer or consumer financed is developed by Chau and de Gorter, making use of a model that explicitly recognizes several consequences of domestic support payments: (a) induce exit or entry; (b) bias production incentives in domestic markets; and (c) cross-subsidize export in global markets.

The key consequences of direct payments can be shown graphically in Figures A1 and A2. In particular, assuming that direct payments are fully decoupled in the traditional sense as in Figure A1, point *a* is always to the right of point *b* in each panel of Figure A1 for the case of U.S. dairy and crops, respectively. Hence, the effects of a consumer transfer policy on demand and consequently on trade distortion is straightforward from panel (a) of Figure A1. $\underline{Q}$ is the payment quota with an associated domestic price $\overline{p}_d$, p_s is the wheat target price, sp_w is the per unit production subsidy for wheat, and $\underline{B}$ is the wheat base acreage. Transfers are area c in panel (a) and area *c* and *d* in panel (b) of Figure A1. Since neither of these two policies affects production decisions at the margin, the effects on production are indirect in that farmers' ability to generate enough revenue to cover costs is affected.

To motivate this indirect effect of the income payment on output through its effect on exit, consider a payment base *B* in Figure A2 for a small country exporter with payments equal to the sum of area *a, b* and *c*. World price (p_w) is below average total costs (ATC^*) so this farmer

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[20] "Infra-marginal" means the marginal cost for output receiving income payments is below the world price and farmers may or may not have to produce in order to receive payments (an example of not having to produce is the production flexibility contract payment scheme of the 1996 U.S. FAIR Act).

[21] Eligibility requires: (i) land is enrolled in acreage reduction programs for any of the crop years 1991 through 1995; (ii) land is planted to program crops under program rules; or (iii) land is enrolled in the Conservation Reserve Program (CRP) and had a crop acreage base associated with it.

would ordinarily exit the industry and produce nothing. We can distinguish between three discrete production outcomes that can result in the presence of direct income payments: Q^*, B or O in Figure A2. First, if ATC is high enough at B (say ATC'_B), it makes little sense for the farmer to produce B if ATC' is greater than $\overline{p}_d$. In addition, the farmer is in fact better off exiting the industry if total revenue net of total variable cost at Q^* (area *a, b, c, d, e* and *g*) is less than total fixed cost (area *a'*, *a, b, c* and *d*), or equivalently, area *e* and *g* is less than area *a'*.

Second, if ATC is given by $ATC_B < \overline{p}_d$, fixed costs (and variable costs at B) are more than covered if the farmer produces at B, since total fixed cost is equal to area *b*, *c* and *d*, while consumer (or taxpayer) financed subsidies raises revenue above market returns at point B by area *a, b* and *c*. The farmer will produce no more than B, however, if world price is lower than p_w' in Figure A2.[22] Profits are thus given by exactly the area *a*.

Third, given that fixed cost (area *b, c* and *d*) is now covered, and that it is profitable to produce at point B, it will also be profitable to produce up to the point Q^*, where the world price is equal to the marginal cost. Output exceeds payment base B, and consumer financed infra-marginal subsidies give rise to strictly positive exports whenever world price p_w is higher than p_w' -- the marginal cost of production at B. Specifically, given an average total cost curve ATC in Figure A2 (a), total profits at Q^* are given by area *a, e* and *g*. Area *a* represents consumer-financed surplus up to the base B. Area *g* represents the variable profits from exports, as world price p_w exceeds average variable cost at Q^*. Area *e* can be interpreted as gains from raising output beyond B due to increasing returns (downward sloping average cost). Thus, profits are positive even though average total cost evaluated at Q^* is strictly higher than the world price ($AVC^* > p_w$), and profits are in fact negative in the absence of the target price (area *c* and *f*).

Two points deserve particular attention. First, it is easy to verify that profits need not be positive at B in order for the target price to cross-subsidize exports. Consider once again the average total cost and average variable cost curves AVC' and AVC in Figure A2a. Total profits are clearly negative at B since ATC' exceeds $\overline{p}_d$. However, if area *a'* is less than the gains from increasing returns (area *e*), plus variable profits from exports (area *g*), the farmer is better off remaining in business and produce Q^*. Second, world price p_w need not even exceed average variable cost at Q^* in order for the target price to cross-subsidize exports. This is shown in panel *b* of Figure A2. In particular, note that profits at B are given by area *a*, and profits at Q^* is given by area *a*, *d* minus *f*. Thus, if area *a* and *d* exceed area *f*, it makes little sense for the farmer to exit. Additionally, if the gains from increasing returns as given by area *d* for all B units of output exceeds variable profit losses from exporting an additional $Q^* - B$ amount (area *f*), the farmer maximizes profits by producing at Q^*.

By allowing profits from one operation (domestic sales) to offset losses from another (exports), cross-subsidization occurs only if the world price is greater than p_w' in Figure A2. The question arises: why would a firm want to finance losses in one operation with profits from another

[22] In particular, since p_w' is just the marginal cost of production evaluated at the payment base B, if world price is less than p_w', producing beyond B can only lower profits as marginal cost exceeds the world price.

operation? From our discussion of Figures A2 (a) and (b), the answer to this question is in fact surprisingly simple. So long as farmers operate at the downward sloping portion of the *ATC* curve, there are clear increasing returns to scale. This allows negative profits to be possible at low levels of production (at *B*, for example), but profits can nevertheless change sign at output levels high enough for exports (Q^* - *B*) to occur in the presence of consumer financed support (or production beyond base for taxpayer financed support) if either: (i) farmers are guaranteed a higher price at low levels of output, or (ii) decoupled direct payments effectively improve farmers' ability to cover costs, and deter incentives to exit the industry when world prices are low.

Summary

Case 1: (Figure A2a with *ATC)***:**

Assumptions: $p_w > AVC$ and $\pi > 0$ at *B*

In the short and long runs, the firm is at Q^*. The firm is making profits of area *a* at *B* in both the short and long runs. The firm wants to keep area *a* so it will move to Q^* iff the cost savings from increasing returns (area *b*) is greater than the extra costs of expanding output (area *f)* that is not covered by the market price p_w. In other words, for the firm to make more profits at Q^* than at *B*, it must be the case that area $b > f$. But fixed costs at *B* = areas *b*, *c* and *d* while fixed costs at Q^* = areas *c*, *d*, *e*, *f* and *g*. Therefore, area *b* = areas *e*, *f* and *g* so area *b* is always > area *f*. So the firm is never at *B* in the short or long run.

Case 2: (Figure A2a with *ATC')*

Assumptions: $p_w > AVC$ and $\pi < 0$ at *B*

In the short run, the firm is at Q^*. In the long run, the firm is at Q^* iff $a' > f' + f$; otherwise it is at O.

The firm is at *B* in the short run only because variable costs are being covered. The firm will expand to Q^* iff the cost savings from increasing returns not covered by revenues (area *a'*) is greater than the extra costs at Q^* not being covered by revenues at p_w (area $f' + f$) less the realized costs savings (area *a*). Areas a + a' are the total cost savings due to increasing returns as output is expanded from B to Q^*. However, the farmer only realizes area *a*. Area *a'* is not a realized cost savings to the farmer; he merely avoid losses equal to area *a'* by choosing to produce at Q^*. In other words, the firm is losing area *a'* at B and will move to Q^* iff losses at Q^* (areas $f' + f - a$) are less.

However, fixed costs = areas $(a' + a + b + c + d)$ = areas $(b + c + f' + f + d + e + g)$, so area a' = areas $(f' + f - a + e + g)$, so area $a' >$ areas $(f' + f - a)$. Therefore, the firm will always produce at Q^* in the short run.

Case 3: (Figure A2b with *ATC)***:**

Assumptions: $p_w < AVC$ and $\pi > 0$ at *B*

(a) At *Q** in short and long runs iff area $b > e + f$
(b) Otherwise, at *B* in short and long runs

Same logic as in Case 1. The firm will expand production of both livestock and crops in the short run if the cost savings from increasing returns not covered by revenues (area *b)* is greater than the extra costs at the expanded level of output not being covered by revenues at the market price (area *e* plus the variable losses of area *f* as well).

Case 4: (Figure A2b with *ATC'*)**:**

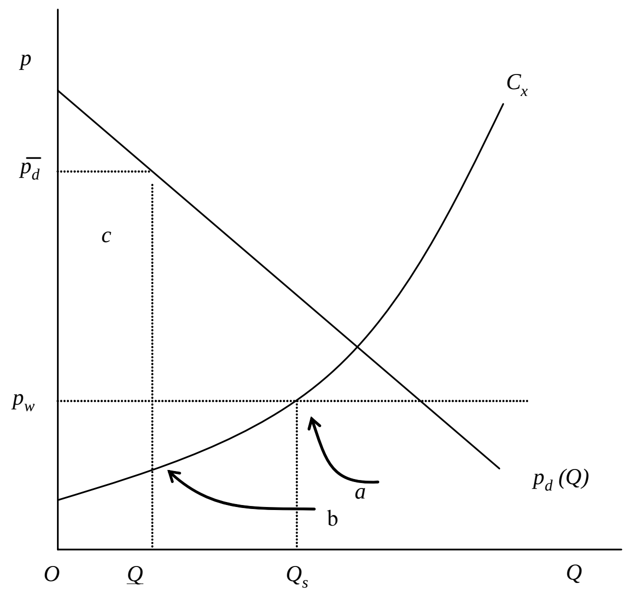
Assumptions: $p_w < AVC$ and $\pi < 0$ at *B*

In the short run, at *Q** iff $a' > e' + e + f$; otherwise at *B* in the short run. In the long run, at *Q** iff profits at *B* (equal to zero in Figure A2b by construction with ATC') $> e' + e + f$. Otherwise, the firm will exit the industry.

The same logic as in Case 2. The farmer stays at the infra-marginal level of subsidized output in the short run only if the revenues above the new average total costs at the infra-marginal output (area *a')* are greater than the extra costs at the expanded output that are not being covered by revenues at the market price (area $e + e'$ plus the variable losses of area *f*). Otherwise, the firm in the short run goes to *Q**.

Figure A1: Decoupled Consumer vs. Taxpayer Financed Infra-marginal Production Subsidies

(a) Consumer Transfer: e.g. U.S. Dairy CCPs



(b) Taxpayer transfer: e.g. U.S crop subsidies

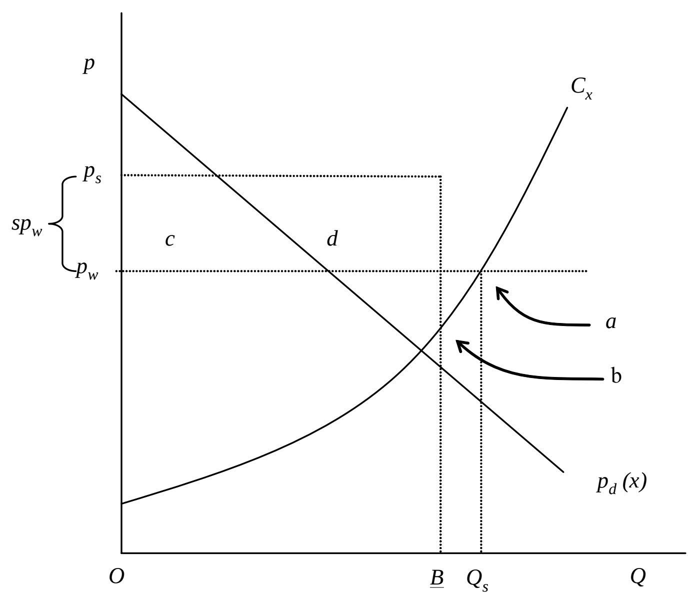
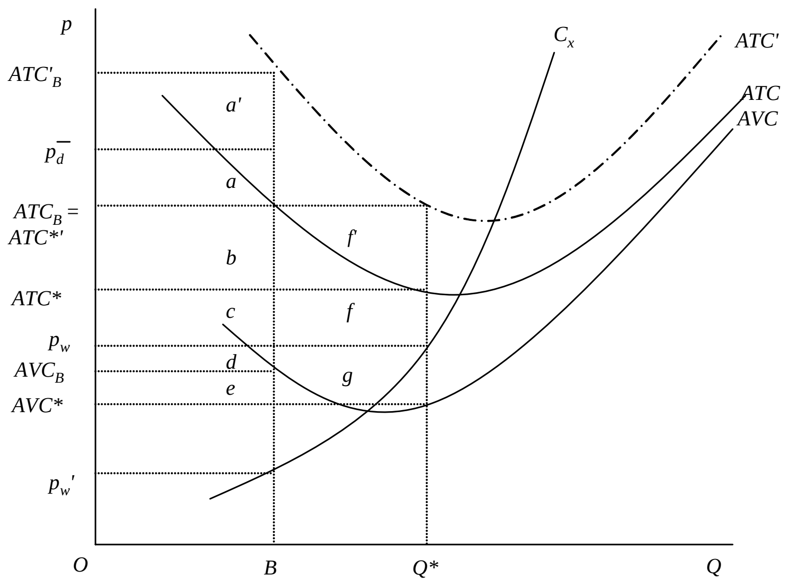
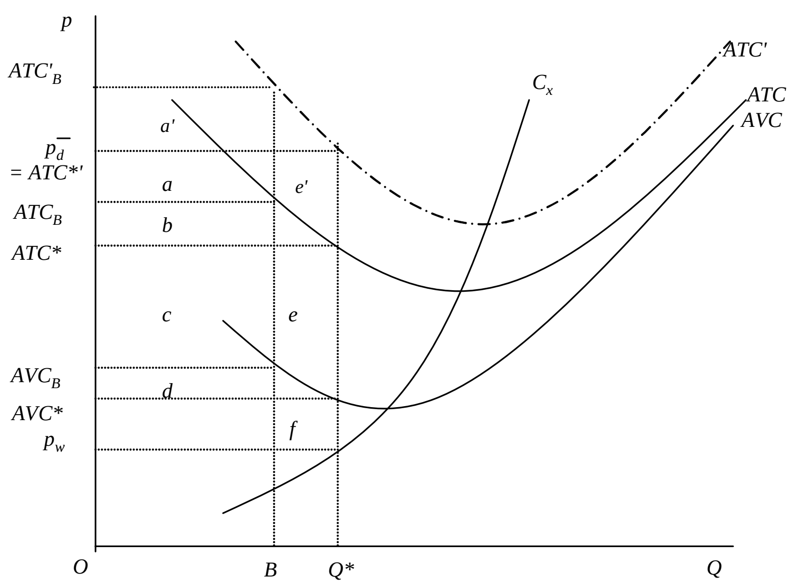


Figure A2: Effects of Direct Income Payments on Fixed Costs and Output

(a) World price above average variable costs at Q* (cases of positive and negative profits at B)



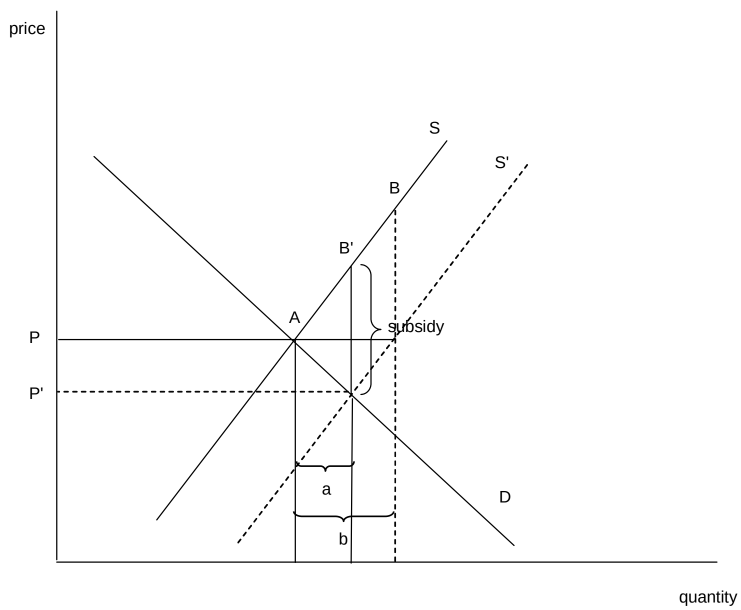
(b) World price below average variable costs at Q* (cases of positive and negative profits at B)



Appendix 2: Analyzing the Net Effect of Subsidies versus Land Set-aside in the CRP

The effect of a subsidy is to move along the supply curve and increase output. If the price P remained constant in Figure A3, then the effect of the subsidy would increase output from point A to point B. Corresponding to this subsidy is an implicit outward shift in the supply curve to S', the size of the shift represented by the distance *b*. However, the downward sloping demand curve D will result in the price to decline to P ' and output will actually increase by only the distance *a*. Nevertheless, the implicit outward shift in the supply curve of distance *b* still occurs. It is this distance we want to compare to the inward shift in the supply curve due to land set aside through the conservation reserve program (CRP).

Figure A3: Implicit Rightward Shift in Supply Curve due to Subsidies



As seen from Figure 3 in the text, the level of acreage set-aside for wheat, feed grains and soybeans is almost 10 percent. The USDA report concludes that 51 percent of the CRP acres would return to production if the CRP was eliminated (Gardner assumed 66 percent but did not have the benefit of the more recent USDA report). We assume the returning land has a productivity of only 80 percent of current acres in production (Gardner assumed land productivity to be 85 percent of current land in production – we ratcheted it downwards to 80 percent because Gardner did not talk about how less non-land inputs will be used per acre on all land in production because total land planted is now higher). Therefore, if the CRP represents 10 percent of current acreage, then the net effect of the CRP is to shift the supply curve inwards by 4 percent (= .8*.51*10).

Table A1 below shows the implicit rightward shift in the supply curve associated with alternative subsidy rates and supply elasticities (holding price constant – this allows us to determine empirically distance *b* in Figure A3). From this, we can then compare directly to estimates of the shift in the supply curve due to the CRP without having to adjust for a downward sloping demand curve and changing prices.

Table A1: Rightward Shift in Supply Curve with Subsidies (%)

	Subsidy rate					
	0.05	0.10	0.15	0.20	0.25	0.30
Supply elasticity						
0.10	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%
0.20	1.0%	2.0%	3.0%	4.0%	5.0%	6.0%
0.30	1.5%	3.0%	4.5%	6.0%	7.5%	9.0%
0.40	2.0%	4.0%	6.0%	8.0%	10.0%	12.0%
0.50	2.5%	5.0%	7.5%	10.0%	12.5%	15.0%
0.60	3.0%	6.0%	9.0%	12.0%	15.0%	18.0%
0.70	3.5%	7.0%	10.5%	14.0%	17.5%	21.0%
0.80	4.0%	8.0%	12.0%	16.0%	20.0%	24.0%
0.90	4.5%	9.0%	13.5%	18.0%	22.5%	27.0%
1.00	5.0%	10.0%	15.0%	20.0%	25.0%	30.0%

What does Table A1 show? The lightly shaded cell indicate the situations where the net effect of subsidies and CRP combined is to shift the supply curve right (the darkly shaded cells indicate situations where the net effect of each policy cancels the other exactly). This means the non-shaded cells are situations where the net effect of both policies is to decrease production. The key number to keep in mind is 4 percent – the shift due to the CRP (hence the darkly shaded cells). As the discussion in the text of the paper indicates, our analysis with subsidy rates for 2003-2004 would fall in the un-shaded area. Gardner's method 1 would be the darkly shaded cell where the subsidy rate is .20 and a supply elasticity of 0.4. Gardner's second method would fall in a lightly shaded cell (cannot identify it because his second method differs in that he uses time series analysis rather than a fixed supply elasticity, etc.).

To illustrate the usefulness of Table A1, what if one has another view about the CRP in that the productivity is only 50 percent on the 51 percent of the 10 million acres set-aside? If the subsidy rate is 10 percent and the supply elasticity is assumed to be 0.2, then do we still have the CRP effect dominating the price subsidy effect? If the CRP land going back into production is 50 percent as productive as current acreage (rather than the 80 percent assumed earlier), then the supply curve shift due to the CRP would be .5*.51*10 = 2.5 percent so the key number now is 2.5 (instead of 4). Any cell that equals or is close to 2.5 is the neutral point where CRP exactly offsets the subsidy effect. Any number above 2.5 means the subsidy effect dominates the CRP effect. For a subsidy rate of 10 percent and a supply elasticity of .2, the number in that cell is equal to 2 which is less than 2.5 so the CRP effect dominates the subsidy effect. One can chose any combination of assumed parameters to come up with your own assessment. This is very helpful because subsidy rates vary from year to year.

To determine the actual change in production, one would have to take the net effects and parameterize across demand elasticities. The change in production is equal to the net shift in the supply curve times 1/(1-1/η) where η is the demand elasticity. The results are in Table A2 below. In that way, one can have variations in both the supply elasticity (captured in the left hand column of the table below) and the demand elasticity.

Table A2: Net Effect of CRP and Subsidies under Alternative Demand Elasticities (% change in production)

	Demand Elasticity													
Net shift in supply curve (%)	-0.5	-0.7	-0.9	-1.1	-1.3	-1.5	-1.7	-1.9	-2.1	-2.3	-2.5	-2.7	-2.9	-3.1
-3.5	-1.2%	-1.4%	-1.7%	-1.8%	-2.0%	-2.1%	-2.2%	-2.3%	-2.4%	-2.4%	-2.5%	-2.6%	-2.6%	-2.6%
-3.0	-1.0%	-1.2%	-1.4%	-1.6%	-1.7%	-1.8%	-1.9%	-2.0%	-2.0%	-2.1%	-2.1%	-2.2%	-2.2%	-2.3%
-2.5	-0.8%	-1.0%	-1.2%	-1.3%	-1.4%	-1.5%	-1.6%	-1.6%	-1.7%	-1.7%	-1.8%	-1.8%	-1.9%	-1.9%
-2.0	-0.7%	-0.8%	-0.9%	-1.0%	-1.1%	-1.2%	-1.3%	-1.3%	-1.4%	-1.4%	-1.4%	-1.5%	-1.5%	-1.5%
-1.5	-0.5%	-0.6%	-0.7%	-0.8%	-0.8%	-0.9%	-0.9%	-1.0%	-1.0%	-1.0%	-1.1%	-1.1%	-1.1%	-1.1%
-1.0	-0.3%	-0.4%	-0.5%	-0.5%	-0.6%	-0.6%	-0.6%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.7%	-0.8%
-0.5	-0.2%	-0.2%	-0.2%	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%	-0.3%	-0.4%	-0.4%	-0.4%
0.5	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.4%
1.0	0.3%	0.4%	0.5%	0.5%	0.6%	0.6%	0.6%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.8%
1.5	0.5%	0.6%	0.7%	0.8%	0.8%	0.9%	0.9%	1.0%	1.0%	1.0%	1.1%	1.1%	1.1%	1.1%
2.0	0.7%	0.8%	0.9%	1.0%	1.1%	1.2%	1.3%	1.3%	1.4%	1.4%	1.4%	1.5%	1.5%	1.5%
2.5	0.8%	1.0%	1.2%	1.3%	1.4%	1.5%	1.6%	1.6%	1.7%	1.7%	1.8%	1.8%	1.9%	1.9%
3.0	1.0%	1.2%	1.4%	1.6%	1.7%	1.8%	1.9%	2.0%	2.0%	2.1%	2.1%	2.2%	2.2%	2.3%
3.5	1.2%	1.4%	1.7%	1.8%	2.0%	2.1%	2.2%	2.3%	2.4%	2.4%	2.5%	2.6%	2.6%	2.6%
4.0	1.3%	1.6%	1.9%	2.1%	2.3%	2.4%	2.5%	2.6%	2.7%	2.8%	2.9%	2.9%	3.0%	3.0%
4.5	1.5%	1.9%	2.1%	2.4%	2.5%	2.7%	2.8%	2.9%	3.0%	3.1%	3.2%	3.3%	3.3%	3.4%
5.0	1.7%	2.1%	2.4%	2.6%	2.8%	3.0%	3.1%	3.3%	3.4%	3.5%	3.6%	3.6%	3.7%	3.8%