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"An economic proposal to decrease agriculture's impact on the environment"

Introduction

While free markets allocate many resources efficiently, in many instances market prices do not reflect the full cost of the production of the good. Thus, the market optimum quantity produced is not necessarily the social optimum. As outlined in the section below, current agricultural practises are not sustainable. It is a pressing issue and must be addressed. I propose that the lack of accounting for the long term effects of farming practises on soil fertility and on the surrounding environment is a failure of the market. Based on environmental economic concepts, I propose a market mechanism to correct for some of the externalities in agricultural production. By taxing land use per crop and artificial fertilizer, it would decrease agricultural land use and reduce excessive fertilizer application rates while increasing natural land conservation measures. I also recommend a few public policy measures to implement in conjunction with these taxes in order to mitigate the social repercussions. By incorporating minimization of resource use, a common ideal in both economics and environmentalism, I am trying to find a way to encourage our society to behave more sustainably and help preserve the future of food production and our planet.

In this study, I evaluate the effect of taxing these inputs on the retail price of protein sources and possible effects on consumption. The pervading attitude in our society maintains that meat is the only suitable source of protein while a small segment of society (mainly animal rights activists and environmentalists) claims that we should all get our protein from vegetable

sources. Given these market mechanisms to make consumers pay the full cost of food, would society shift towards the latter ideal? Using data on yields and fertilizer application rates, I demonstrate the effect these taxes would have on the relatives prices of six sources of protein in Canada. In addition, I suggest ways to measure how these changes in prices would affect consumption patterns.

Environmental problems due to conventional agricultural methods

As with many of our industries, we are using our agricultural resources unsustainably by drawing on the environmental capital at a faster rate than it can replenish itself (Ruttan 1999; Tilman 1999; Tilman 2001). Current agricultural practices have degraded the natural fertility of the land through soil erosion, soil compaction, acidification, salinization, and loss of organic matter and nutrients (Montgomery 2007; Dearden and Mitchell 2001; Scherr 1999). As well, in a time of diminishing freshwater stocks, agriculture is a water intensive industry (Warda and Pulido-Velazquez 2008; Gordon et al. 2005; Jury and Vaux 2005). In addition to the unsustainable use of agricultural resources, conventional agricultural practices damage the surrounding environment. First, artificial fertilizer runs off into the waterways. The increased levels of nitrogen, phosphorus and potassium in the aquatic ecosystem trigger eutrophication. Eutrophication leads to lower concentrations of dissolved oxygen in waterways, reduced biodiversity and even aquatic dead zones in extreme cases (Jackson 2008; Kramer et al. 2006; Carpenter 2005; Rabalais 2002; Vitousek et al. 1997). Second, pesticide use in agriculture increases toxicity levels in the environment and threatens the survival of many species (Thomas 1999). Third, the vast amount of land devoted to agriculture reduces the land available for natural habitats which leads to species extinction and loss of ecosystem services (Tilman 2001). In addition, each year we are converting more natural land to agriculture, estimated at a total of

10^9 hectares by 2050 (Tilman 2001). Once we reach the physical limits of arable land, the environmental issue will become a social issue when there is no more land for growing food (Meadows 2004). Fourth, the machinery used in farming emits noxious gases and greenhouse gases contributing to pollution and climate change (plus the gases livestock produce).

Corrective tax proposal

This paper addresses three of the issues mentioned above. In economic terms, the producer and the consumer are not paying the full cost of agriculture production. The environmental externalities are assumed by society both in the immediate and distant future. To put a market cost on land being diverted from natural habitat and associated ecosystem services, the first corrective tax I am proposing would be on the average land use of a crop. Such a tax would encourage consumption of agricultural products that use the lest land for the most output, i.e. land efficient products. To put a market cost on the environmental externalities of fertilizer and to give a market incentive to use soil conservation practices, the second corrective tax I am proposing is on artificial fertilizer (N, P and K). Reduction of fertilizer use to a socially optimal level has multiple benefits. First, it would encourage consumption of food that requires less fertilizer inputs. Second, decreased fertilizer use would result in less fertilizer run-off and associated problems. Third, as the cost of fertilizer increases, the relative cost of soil conservation measures, i.e. ways that naturally maintain soil fertility to achieve similar yields, would decrease. Currently, the market costs of conserving the soil and sustainable land management practises are higher than the cost of increased fertilizer use or the increased income from higher yields due to better natural fertility of the soil. In a sense, the high levels of application of fertilizer mask temporarily the decreased fertility of the soil due land degradation (Meadows 2004). In the long run, techniques such as crop rotation, contour cultivation, no-till

agriculture and raised bed agriculture would increase the fertility of the soil and decrease land degradation (Triplett 2008; Govaerts 2007; Mohammaddoust-e-Chamanabad et al 2007; Chen 2006). These are costly measures that would only be economical if the full cost of artificial fertilizers was included in the market cost. These land conservation measures have been shown to reduce the rates of application of fertilizer and achieve the same yields (Triplett 2008; Pimentel 2005). Thus, land degradation, whose costs are estimated at 1 billion $/year in Canada (soil erosion 707M$, soil compaction 68-200$, acidification and salinization), would be assumed more directly by the farmer and the corrective taxes would be a market incentive to reduce the strain on the land (Dearden and Mitchell 2001). Fourth, the value of compost and such natural fertilizers would increase thus encouraging their use and the natural cycling of renewable nutrients. These corrective taxes provide market incentives to modify consumer choice and to alter production practices.

The main focus of this paper is on the effect of these taxes on the relative retail prices of vegetable vs. animal protein sources. I also suggest that it would modify consumption patterns of protein sources. In addition, I evaluate in economics terms a common claim made by environmentalists to eat a vegan diet in order reduce the strain on the environment. If the full cost of the agricultural production is included in the cost of protein products, would it result in less meat and more legumes produced? Few of the problems often associated with meat are inherent to meat production (except soil compaction and emissions of CH_4), most of the issues lie in the fact that producing each kilogram of meat involves producing multiple kilograms of grain, thus having a greater impact as more is consumed. As well, I am providing an alternative solution to the debate between intensive (high yields and many environmental problems) and extensive (low yield and high amounts of land) agriculture. By taxing both the land and the

artificial inputs, my proposal would affect consumption and thus reduce both sides of the environmental problems associated with agriculture.[1]

This paper challenges the mainstream assumptions in our Western society that meat is the only source of protein and that cheap food is necessarily a good thing. Putting that into perspective, Canadians get less than 10% of their protein from non-animal sources (FAO 2008). Instead of taxing agricultural inputs, our governments subsidize inputs such as fertilizer and pesticide and encourage high production techniques which degrade our land (average subsidies in Canada are roughly 43$/ha at a total of 4B$/year (OECD 1998)). We encourage government programs that make food cheap and plentiful, yet cheap food encourages waste of food and inefficient use of our resources. As well, there is a strong focus on meat and fish as the best sources of protein. A glance at many of the Canadian government publications shows that the government does not consider other sources of protein. Until the most recent publication in 2007, the Canadian food guide all but ignored vegetable sources of protein (Health Canada 2002). On the consumer price index, many cuts of beef are included but not a single source of vegetable protein (Stats Canada 2008). Our society has been conditioned to embrace meat, cheap food and its advantages.

Study Variables and Limitations

My model evaluates the change in the relative retail cost of six sources of protein if artificial fertilizers and land use were taxed in Canada. I am treating Canada as a closed system without

[1] Agricultural production can actually be made into a closed circle of reproduction: removal of organic matter from the ground (i.e. food), transformation of food by our bodies and removal of biological energy, waste products returned to the land (compost and human manure), radiant energy from the sun captured by plants, removal of food. However, at the intense level of agriculture that our population and consumption patterns demand, it is not such a perfect cycle of energy and nutrients. Mainly, waste products are not returned to the land and the soil is not being preserved adequately.

imports or exports. If this policy were to be implemented, it would have to apply to imports as well as domestically grown food.

I evaluate six sources of protein split into animal and vegetable sources. First, beef (cows), pork (pigs) and poultry (chicken) represent animal sources. Second, lentils, chickpeas and soybeans represent the vegetable sources. I choose these six on the basis of their popularity (determined by availability of information). I am using these six sources as case studies to draw conclusions about the effect of a tax on agricultural inputs on the relative price of animal vs. vegetable sources of protein and about the effect on consumer consumption.

There are a few sources of protein that are not considered in this study. To keep this study manageable, I did not look at animal products such as milk, cheese, eggs, etc. Also, I did not include hydroponic agriculture nor urban agriculture. In addition, comparing land agriculture with farmed or wild fish would have been complex to the point of impossible. Thus, while I acknowledge that there are other sources of protein, I ignored roughly a fifth of an average Canadian diet (FAO 2008).

As well, it is beyond the scope of this study to evaluate the influence of a tax on water, pesticides and emissions, although they are significant factors that contribute to environmental degradation. If my taxes were to be implemented, it would need to be in conjunction with taxes on these other factors in order to avoid farmers shifting towards greater use of these resources and higher rates of pollution with worse environmental impacts than their current methods.

Methodology and Results of Economic Model

For the land tax, a fixed rate would be set per hectare of land that it takes on average to produce a kilogram of a given crop. To determine the average amount of land used per crop, I have used the average yield values in Canada determined by the Food and Agriculture Organization of the United Nations (FAO). The data was given in tonnes of crop/ha which I converted into ha/kg of crop, see Table 1. The results would then be used as the basis for the land tax (the rate of the land tax is variable and would gradually increase over the years).

Table 1. Average yield in Canada per crop. Source: FAOstat 2000-2003 for Canada

	kg/ha	ha/kg
Chick peas	1132.1	0.00088
Lentils	1018.1	0.00098
Soybeans	2131.8	0.00047
Maize	6933.8	0.00014

Retail price of crop/kg of crop=Total costs of production/kg of crop + (land tax rate*ha/kg of crop)

To model the effect of the land tax on the retail cost of the six agricultural products in this study, I used data for the retail cost from Statistics Canada wherever possible and from prices recorded directly in grocery stores and the yield values from the FAO. For animal products, I used the total feed an animal eats before it is ready for human consumption to approximate the land appropriated in the production of the food. The figures are around 7kg of grain for 1 kg of beef, 4kg for 1kg of pork and 2kg for 1kg of poultry (Aiking & de Boer (2006); Smil (2000); WorldWatch (1998)). Assuming animals eat maize as their primary source of food and those figures, I applied the land tax on the amount of land used to grow the feed per kilogram of animal product. In other words the land tax for animal products was calculated in the following way:

ha/kg of meat=kg of grain/kg of meat*ha/kg of maize

I have made two models, an algebraic model (see Fig. 1) where the rate of the land tax is the variable and an example for all six products with an actual land tax rate to generate an actual retail price.

Fig. 1 Retail price with varying land tax rate

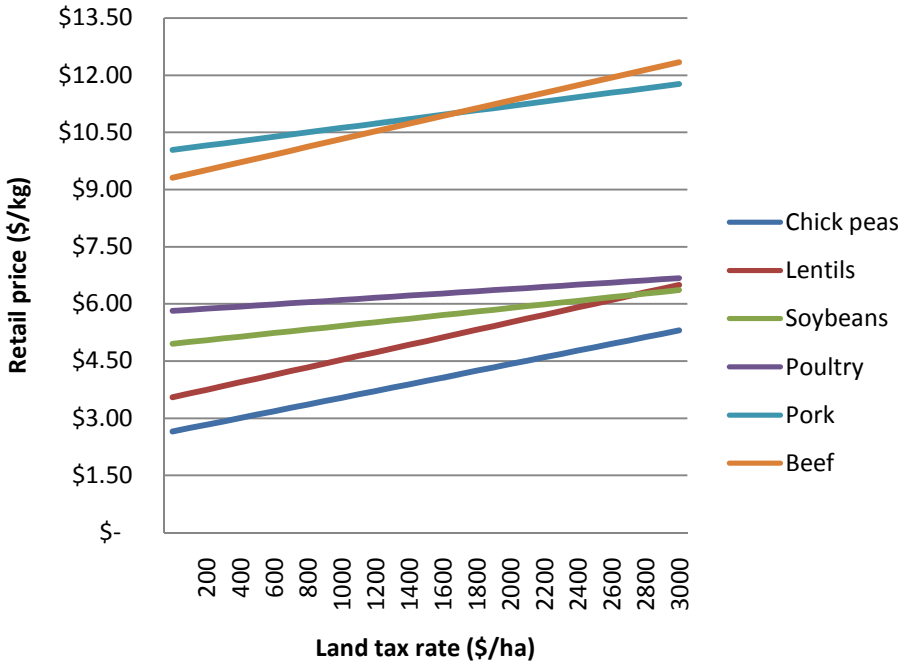


Table 2: Fertilizer Application Rates in Canada. The values for chickpeas and lentils were based on recommendations and those for soybeans and maize were based on average rates in Canada.

For the fertilizer tax, it would be relatively simple to apply in the real market. Each kg of fertilizer would have a set tax that would be included in the price the farmers pay for fertilizer. The increase in fertilizer costs would be passed down to the consumer in a competitive market.

Retail price/kg of crop=Total costs of production/kg of crop+(fertilizer tax rate*kg of fertilizer/kg of crop)

To model the effect of the fertilizer tax on the retail cost of the six agricultural products in this study, I used data on average fertilizer application rates and recommended rates for Nitrogen (N), Potassium (K and Phosphate (P) per crop from FAO and the Research Institute of Montrana (and compared it to other groups recommendations), see Table 2. For animal products, I proceeded in the same way as for the land tax. (I took average grain consumption per kg of animal product and then took the average fertilizer for that grain consumption). In Table 3 and Figure 1, I calculated sample effects on all six products.

Sources: Research Institute of Montana for Chickpeas and Lentils and FAO Stats 2000 on Canada for soybeans and maize

	N (kg/ha)	P (kg/ha)	K (kg/ha)	total kg fert/ha	kg of fertilizer per kg of crop
Chickpeas	27.5	27.5	32.5	87.5	0.077
Lentils	27.5	27.5	32.5	87.5	0.086
Soybeans	25.0	50.0	85.0	160.0	0.075
Maize	156.0	52.0	95.0	303.0	0.044

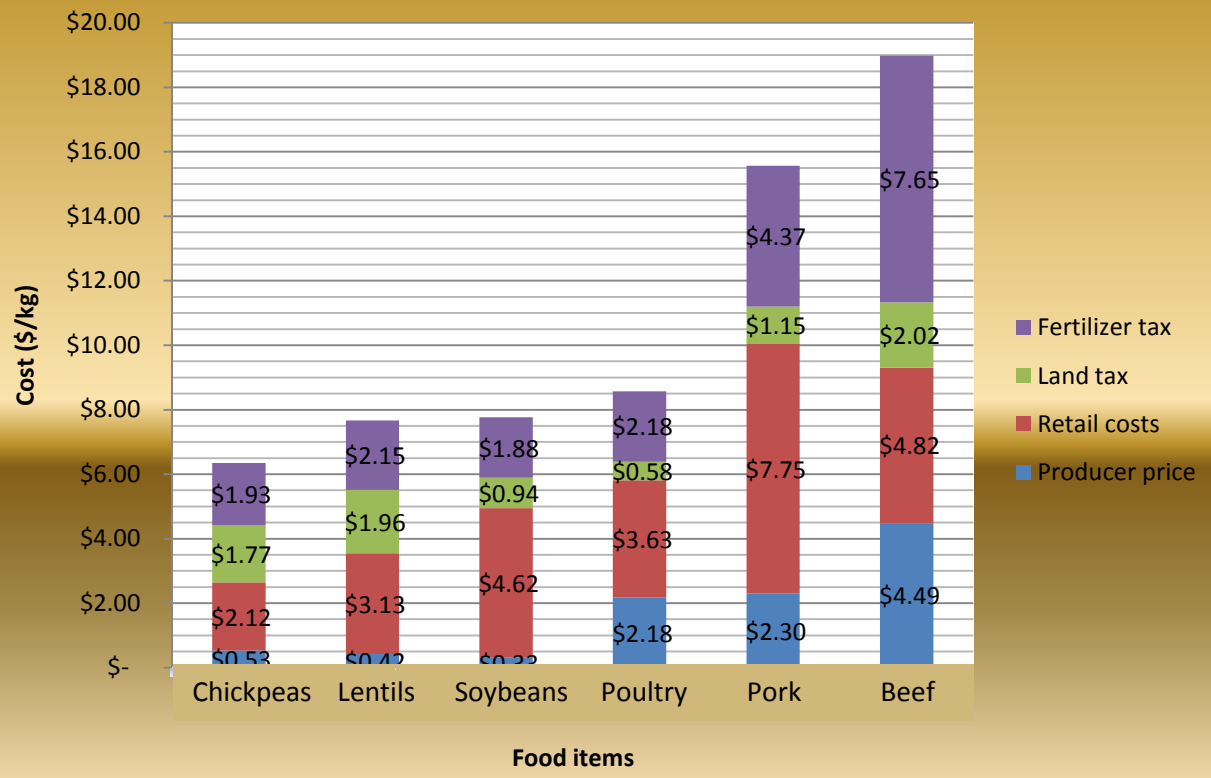
Table 3: Initial prices and prices with corrective taxes.

	Producer price	Retail costs	Retail price	Yield (ha/kg of crop)	Land tax at 2000$/ha	Price with land tax	kg of fertilizer per kg of product	Fertilizer tax at 25$/kg	Price with fertilizer tax	Price with both taxes
Chickpeas	$0.53	$2.12	$2.65	$9x10^{-4}$	$1.77	$4.42	0.077	$1.93	$4.58	$6.35
Lentils	$0.42	$3.13	$3.55	$1x10^{-3}$	$1.96	$5.52	0.086	$2.15	$5.70	$7.66
Soybeans	$0.33	$4.62	$4.95	$5x10^{-4}$	$0.94	$5.89	0.075	$1.88	$6.83	$7.76
Poulty	$2.18	$3.63	$5.81	$3x10^{-4}$	$0.58	$6.39	0.087	$2.18	$8.00	$8.57
Pork	$2.30	$7.75	$10.04	$6x10^{-4}$	$1.15	$11.20	0.175	$4.37	$14.41	$15.57
Beef	$4.49	$4.82	$9.31	$1x10^{-3}$	$2.02	$11.33	0.306	$7.65	$16.95	$18.97

Source: Producer prices from FAOstat for Canada 2000-2003; Retail prices from StatsCan 2004-2008 and grocery store data 2009; Yield and Fertilizer from FAOstat as described in Table 1 and Table 2

Note: all prices in 2009C$/kg

Figure 2. Cumulative cost of products to the consumer based on producer costs, retail costs and the two proposed taxes. (see Table 3 for list of costs and calculations) Each bar is the cost of a product: chickpeas, lentils, soybeans, poultry, pork and b



Public policy proposal

In order to ease the implementation of this tax, several measures should be incorporated into the policy proposal. All of these measures would be announced as part of the package.

First, the rate of the corrective tax should be increased gradually to be effective without causing large disturbances in society. On the production side, a gradual increase would allow farmers to adjust their agricultural methods to more efficient ones (in terms of soil conservation) and to produce more efficient goods without suffering significant losses. On the consumer side, people would be able to slowly shift their diets towards food that was produced more efficiently. In addition, gradual adjustment gives the government a way to monitor the effects of the tax and to set it at an appropriate fixed level, thus avoiding the difficulty of forecasting an accurate rate of taxation and the possibility of setting an incorrect rate.

Second, the government would need to provide information to farmers and to the public about more efficient methods and products. From an economic standpoint, information, and the research that leads to that information, is a public good, used at zero cost. Thus the government, with public funding, is well suited to fulfill the role of funding the research and disseminating it (Stiglitz and Charlton 2005). On the production side, the government would need to help farmers farm more sustainably and use less resources for similar yields. On the consumption side, the government would need to provide nutritional information about protein substitutes as well as recipes for non-animal protein dishes (e.g. chickpea stir-fry, tofu salads, etc).

Third, some of the increased tax revenue from the corrective taxes proposed would replace some of the revenue from income taxes and the goods and services tax. First, the impact on family budgets would be mitigated (as the portion of money spent on total food expenditures

increases, the portion spent on other forms of taxes would decrease by a similar amount). Second, a decrease in taxes in other sectors of the economy would decrease the deadweight losses and encourage efficient market allocation. Of course, the cost of food will increase more than the revenue from the corrective taxes as farmers shift towards sustainable farming methods that reduce their fertilizer use but increase their farming costs. Therefore, the entire increase in the cost of food could not be diverted from other tax expenditures.

Fourth, to avoid depriving low income families of food, the policy would include tax rebates. This would be similar to the GST tax rebate that the Canadian government currently allots to low-income families. The quarterly amount paid out to families is an approximation of the low income family's expenditures on the GST over each quarter (www.cra-arc.gc.ca). Additionally, a tax rebate would be the equivalent of a decreased income tax rate for families that pay income taxes.

Additional Research

Before this could be suggested seriously as public policy, additional research would need to be carried out to evaluate the possible influence of these taxes on farming methods and on consumer demand.

For the farming methods, it would be necessary to quantify the cost of soil conservation practices, the decrease in artificial fertilizer use and the changes in yield. The scientific part of this additional research would be based on agricultural ecology and the financial part of it conducted by collecting data on the market cost of the techniques (as well as the general breakdown of production costs).

To ascertain the effect of these taxes on consumption, a survey could be given to a large sample of people (e.g. 1000) that would include questions on how changes in price would affect their consumption of vegetable and animal protein products. The protein content of food and nutritional needs would be clearly outlined as well the expectation that total expenditures on food would likely increase. In addition, it would be made clear that there would be a reduction in income tax as well as a tax rebate for lower income families to allow for a larger budget on food expenditures. To get some values for elasticity of demand (and cross-price elasticity of demand), the survey would include questions on current food consumption habits (i.e. number of meat dishes and number of vegetable protein dishes) and expected changes in those habits if the prices changed. The aim of this study would be to see if an increase in price would shift people's diets away from the input intensive agricultural products (i.e. beef and pork) or if people would eat less than adequate protein or keep eating as before. Also, to generate data on income elasticity, it would split respondents into income categories.

Conclusion

In this public policy proposal, I attempted to find a way to incorporate environmental and social externalities into the market for agricultural products. In addition, through the policy measure I suggest, environmental taxes on land and fertilizer could benefit all of society without significant repercussions. While these taxes might be impractical in many ways which I leave up to my critiques to figure out, a gradual elimination of our agricultural subsidies would have many of the positive effects I had hoped to achieve with the taxes. Instead of encouraging efficient use of agricultural resources through the taxes on land and fertilizer I propose, our society encourages their overuse. Meanwhile we are destroying our environment and the natural resources we draw on to feed ourselves, putting future generations in peril.

When I first began the research for this project, I had thought that I could find a way to encourage the consumption of vegetable protein sources and discourage the consumption of animal protein sources. Instead, through analysis of data, I reached the surprising conclusion that consumption of poultry has similar environmental impact to that of lentils, chickpeas or soybeans. At the very least, my research has illustrated the relative impact of different animal sources of protein. However, there are other factors which were not included in the accounting which might favour vegetable protein consumption. For example, I assumed that animals only eat maize, an extremely productive crop while animals also consume hay, soybeans and other grains with lower yields. If I had included other types of feed, the land use for animals would likely have increased. In addition, much of the legume production in Canada is on marginal land while maize is grown on very productive land, thus affecting average yield rates. As well, it is possible if the same government funding for maize production were diverted to legumes, yields

for legumes could increase. Thus, additional research into the breakdown of animal feed and into the relative productivity of crops on the same land could significantly alter my results.

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Appendix 1: Data Tables for prices of 6 sources of protein

Table 1: Canadian producer prices adjusted for inflation from 2000-2003 (in 2009C$/tonne)

Prices adjusted for inflation	2000	2001	2002	2003	2000-2003 average	average in C$/kg
Beans, dry	$598.56	$699.76	$589.84	$533.28	$605.36	$0.61
Chick peas	$573.57	$534.09	$514.97	$512.17	$533.70	$0.53
Lentils	$426.01	$361.46	$412.89	$488.84	$422.30	$0.42
Soybeans	$312.96	$301.22	$332.35	$363.30	$327.46	$0.33
Chicken meat	$2,196.70	$2,257.99	$2,102.99	$2,167.78	$2,181.37	$2.18
Pig meat	$2,493.01	$2,578.90	$2,059.89	$2,055.35	$2,296.79	$2.30
Cattle meat	$4,623.07	$4,856.59	$4,496.37	$3,966.27	$4,485.57	$4.49
	C$/tonne	C$/tonne	C$/tonne	C$/tonne	C$/tonne	C$/kg
Source: www.fao.org						

Table 2: Canadian retail prices of food adjusted for inflation from 2004-2009 (in 2009C$/kg)

	2004	2005	2006	2007	2008	2004-2008 average
Beef average	$9.57	$9.37	$9.16	$9.03	$9.41	$9.31
Pork chops	$11.07	$10.38	$10.14	$9.32	$9.29	$10.04
Chicken	$5.72	$5.64	$5.51	$5.82	$6.36	$5.81
Source: www.statscan.gc.ca						

Table 3: Canadian retail prices of food (grocery store data) in 2009C$/kg

	Extra Foods	IGA	SaveOn Foods	Average
Chickpeas	$2.70	$2.00	$3.26	$2.65
Lentils	$3.96	$2.80	$3.90	$3.55
Soybeans	N/A	$3.00	$6.90	$4.95
source: grocery stores in Squamish and Vancouver in 2009				

Appendix 2: Agriculture Data

Table 3: Average Yield in Canada

	2000	2001	2002	2003	hg/ha	kg/ha	ha/kg
Chick peas	13682	9734	11087	10781	11321	1132	0.0009
Lentils	13288	8527	9200	9707	10181	1018	0.0010
Soybeans	25483	15297	22814	21679	21318	2132	0.0005
Maize	62844	66186	70127	78193	69338	6934	0.0001
Source: FAOstat 2000-2003 for Canada							