RESEARCH NOTE
JANUARY 2015

ECONOMY WIDE AND EMERGING ISSUES

Growing Risk:

The impact of changes in agricultural production on consumer expenditures in Canada

Summary of Impacts and Investment Implications

Sustainable Prosperity is a national research and policy network, based at the University of Ottawa. SP focuses on market-based approaches to build a stronger, greener, more competitive economy. It brings together business, policy and academic leaders to help innovative ideas inform policy development.

- This is Sustainable Prosperity and Greenchip Financial's first attempt at testing an investment theory on the third-order economic and financial impacts of climate change and climate change policy. Put simply, our investment theory is that the effect of climate change on the price level of sectors more directly impacted and vulnerable to environmental risks (such as agriculture to climate change) will trickle down and affect the rest of the economy through the effect on prices, consumer budgets, and corresponding shifts in consumption.
- This report uses an economic model (see Appendix 1 for details) to project the impacts on prices, quantity consumed and revenue implications for various sectors of the Canadian economy, based on an assumption of changes to agricultural productivity brought about by climate change.
- There has been very little research on how a change in agricultural productivity will reverberate through the economy. This study interprets the investment implications of changes in price, quantity demanded and revenue demanded at the sectoral level across the entire economy of two agricultural productivity scenarios using a computable general equilibrium (CGE) model.
- The two scenarios are based on moderate figures (+/-10% change in agricultural productivity) that fall on the low end of the range of expected impacts of climate change on agricultural productivity in Canada. The focus of the investment implications is on the 10% decrease scenario.
- **Price Impacts:** Not surprisingly, under a scenario where agricultural productivity falls by 10%, the most impacted sector is food and non-alcoholic beverages, which would see a 4.4% price increase, while restaurants and accommodation services would experience a 1.2% price increase. On the negative side, there would be a 1.4% fall in price for housing purchases and 1.1% fall in recreation (e.g. sports and entertainment) prices.
- **Quantity Impacts:** Given that many sectors that face a rise in costs will pass these on in the form of higher prices, the corresponding impacts on consumer expenditures depend on the price elasticity for that sector. For example, food is considered to be an inelastic good, so consumption only falls by 1.8% when prices rise by 4.4%. For most sectors, there is a fairly uniform fall in consumption across the board as a reaction to increased prices in a few sectors. The sectors seeing the greatest decrease in consumption are restaurants and accommodation services (i.e. hotels), other non-durables (e.g. televisions and electronics), alcohol and tobacco, and net expenditures abroad (i.e. vacations).

- **Revenue Impacts:** A decrease in productivity in the agricultural sector would actually raise sector revenues for food and non-alcoholic beverages (+2.52%) as well as for restaurants and accommodation (+0.19%). All other sectors would experience negative revenue impacts, with the largest drops experienced by owned living quarters (-1.79%), recreation (-1.50%), and electricity, other transport and motor vehicles and parts (all -1.20%). Least affected among non-food related sectors were other non-durables (-0.50%) and other semi-durables, other services, net expenditures abroad and rented living quarters (all -0.9%).
- **Investment Implications:** While the percentage effects on revenues are relatively small, the more affected sectors are either more discretionary or larger budget items such as recreation, houses, cars and other durables. The less affected sectors are less discretionary non-durables and services.
- **Conclusion**: Given an equal revenue impact, sectors with a greater price drop will experience a greater drop in profitability. From our results, owned living quarters and recreation stand out as the most vulnerable. The vulnerability of recreation, as the most discretionary category, provides some confirmation of the risks to discretionary sectors of third-order effects of climate change and/or resource scarcity.

Climate Change and Agriculture

Environmental trends, particularly declining water availability, soil depletion, and climate change, will impact food production in Canada and globally. These trends will change the growing conditions for agriculture by impacting temperatures, rainfall patterns, length of growing season, and fertilizer requirements. In some scenarios they may have a positive impact on agricultural productivity, and in other scenarios the effect is likely negative. In 2012, many key agricultural regions of the United States experienced the adverse effects of climate change. The drought of the summer of 2012, the most severe in 25 years, affected 80% of agricultural land in the United States, and will likely continue to adversely affect food prices.[1] This demonstrates the vulnerability of agricultural production to climate change.

Sustainable Prosperity,[2] together with Greenchip Financial, used a computable general equilibrium (CGE) model to examine the impacts of environmental trends on prices and consumer expenditures in a wide range of sectors using several scenarios.[3] The goal of the modelling exercise was to examine how the impacts of climate change on agricultural productivity and water use might ultimately impact consumer spending patterns.

This paper is organized as follows: first, the general investment theory is presented. The results of the modelling are presented and then interpreted for investors. Then the modelling scenarios and associated assumptions are presented in an appendix.

Investment Theory: Environment and Resource Scarcity Risks

Investment theory and analysis, in considering the impacts of climate change and resource scarcity, tends to focus on first-order and second-order effects.

First-order effects are those describing the direct effects of environmental trends, such as resource scarcity or climate change, and related government policies, on affected sectors. For example, these studies examine how the energy sector would be impacted by a carbon pricing policy, or how the agricultural sector is impacted by soil depletion.

[1] United States Department of Agriculture, August 31, 2012. U.S. Drought 2012: Farm and Food Impacts, http://www.ers.usda.gov/newsroom/us-drought-2012-farm-and-food-impacts.aspx.

[2] Sustainable Prosperity would like to thank Dr. Nicholas Rivers, Chairholder, Canada Research Chair in Climate and Energy Policy, University of Ottawa for the CGE modelling support.

[3] The CGE model used is a "standard" CGE model, meaning that it follows the same assumptions as well-known models, such as that of the MIT Joint Program on the Science and Policy of Global Change. For details see: http://web.mit.edu/globalchange/www/MITJPSPGC_TechNote6.pdf.

The second order effects describe how the resulting changes in resource and other input prices impact companies that use these inputs in their production processes. Cost structures and production functions for these companies will change depending on the substitutability of resource inputs and other factors. For example, the steel sector would be impacted by an increase in energy prices, or the food processing sector affected by an increase in prices for specific non-substitutable agricultural inputs. These direct and indirect environmental effects are assessed by investors in order to determine "winners and losers", and to help inform investment decisions.

But the cascade of effects can be explored further, and the results of that exploration can help inform investors that are interested in sectors of the economy other than those affected by first- and second-order impacts.

In that context, the analysis presented here focuses on how disposable income and consumer spending could be impacted by environmental trends and related policy responses. It is widely expected that growing resource scarcity will translate into higher prices for food, energy and other key inputs, which will lead to a reallocation of the factors of production. Labour, capital, raw materials, technology and other inputs will be redistributed according to price signals, which will also have productivity implications. Households will also reallocate their expenditures and savings, as companies pass costs on to consumers.

The basic analytical framework can be described as follows:

Companies can pass on costs in the following ways:

- Products with **inelastic[4] demand** will pass all costs on to consumers in the form of higher prices; and,
- Products with **elastic demand** will pass costs onto workers in the form of lower wages.

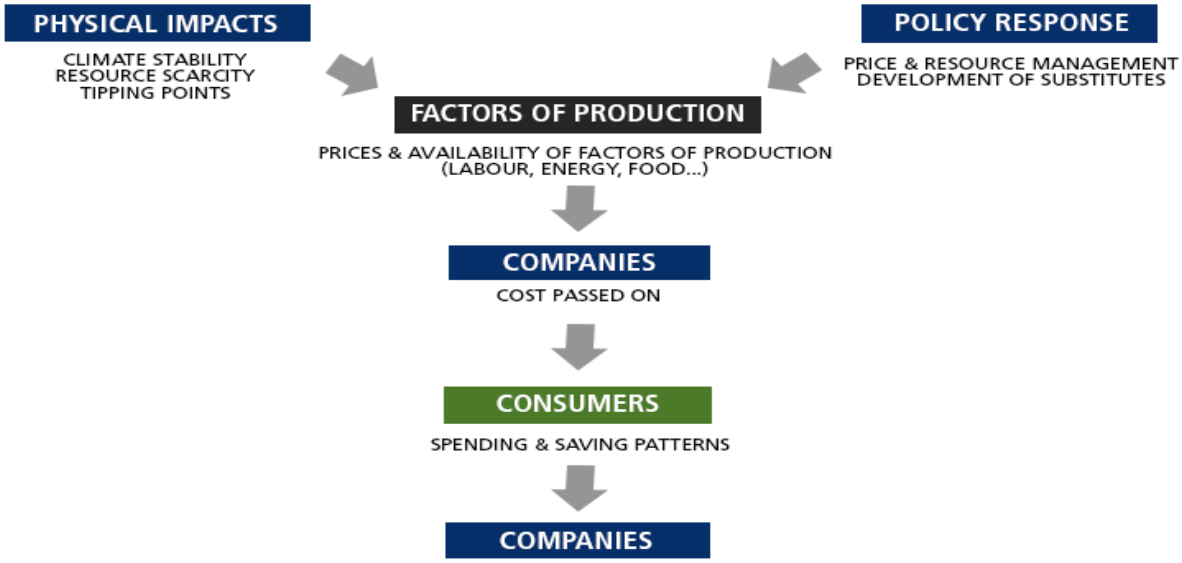
Our investment theory begins by assuming that an increase in prices of essentials leads to a reduction in disposable income, and a corresponding decline in non-essential consumption. Consumers, having to devote a greater share of their income for things they must have, are left with less with which to buy things they would like to have. Consumers will have less money available to spend on non-essentials, such as televisions, vacations and restaurant meals. Environmental trends and policy responses will therefore change consumer discretionary spending and saving patterns in the short-term. Companies will also face shifting labour, capital and other input markets. Consumer-facing sectors will be indirectly impacted by environmental trends through the interaction of changes in input markets and consumer spending.

Besides the physical risks of environmental trends, the economy will also be affected by the policy response to these trends by

[4] Price inelastic products are those whose demand is not highly responsive to changes in price. Correspondingly, demand for price elastic products is responsive to price changes.

governments. The physical impacts of environmental and resource scarcity issues will manifest differently than those arising from the implementation of a policy. Policies are generally implemented gradually; giving companies time to make adjustments and may even include compensatory measures; whereas physical impacts are more likely to be unpredictable, sudden shocks with high price tags. Physical impacts can also manifest over time (e.g. increasing water scarcity in a particular region), but they are still much more difficult to forecast accurately. The policy responses from governments to address resource constraints are expected to include price and resource management (short-term) and encouraging of the development of substitutes (long-term). The concept is summarized in Figure 1 below.

Figure 1: Concept Overview



It is important to note that these are short-term impacts: over a longer time period, changes in consumption patterns and the development and availability of substitutes will likely result in further adjustments.

Scenarios

The economic modelling considered two main scenarios:

- 10% rise in agricultural productivity; and,
- 10% fall in agricultural productivity.

Appendix 2 details the impacts of climate change on agriculture, including predictions for Canada, which serves as a rationale for the selection of these scenarios. These scenarios are not meant to be predictions of what we believe will happen to Canadian agricultural production. As noted in Appendix 2, there are many different predictions for many different crops, regions and time periods. These scenarios are on the low end of the predictions in terms of the increase (or decrease, in some cases) in overall agricultural productivity.

Agricultural productivity refers to the ratio of outputs (yields) to inputs. The key inputs into agricultural production are arable land, water, technology, labour, finance, fertilizer and seeds. The economic model interprets a fall in agricultural productivity to translate into the need for more inputs. Depending on the ratio of inputs (e.g. labour, fertilizer, etc.) used to produce a given crop, the model assumes that proportionally more of every input is required to create the same unit of output (i.e. the crop). Obviously this is a simplified assumption.

The scenarios are meant to be illustrative of how the Canadian economy may react to these two scenarios. We did not consider the role of international trade in our analysis. When it comes to climate change and agriculture, Canada is predicted to be one of the least impacted countries due to our Northern geography. The literature suggests that the impact of climate change on agriculture is likely to be more severe in other countries than in Canada.

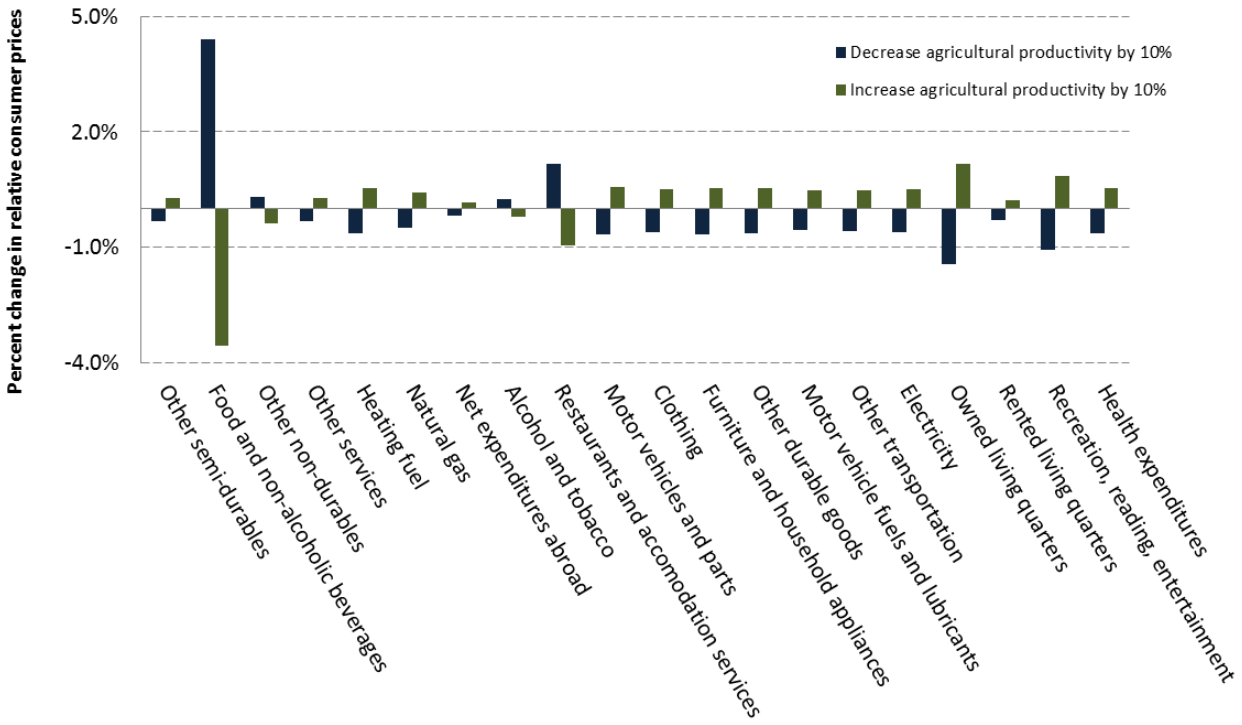
Results

We examined two groups of impacts:

- Consumer prices;
- and Quantity consumed.

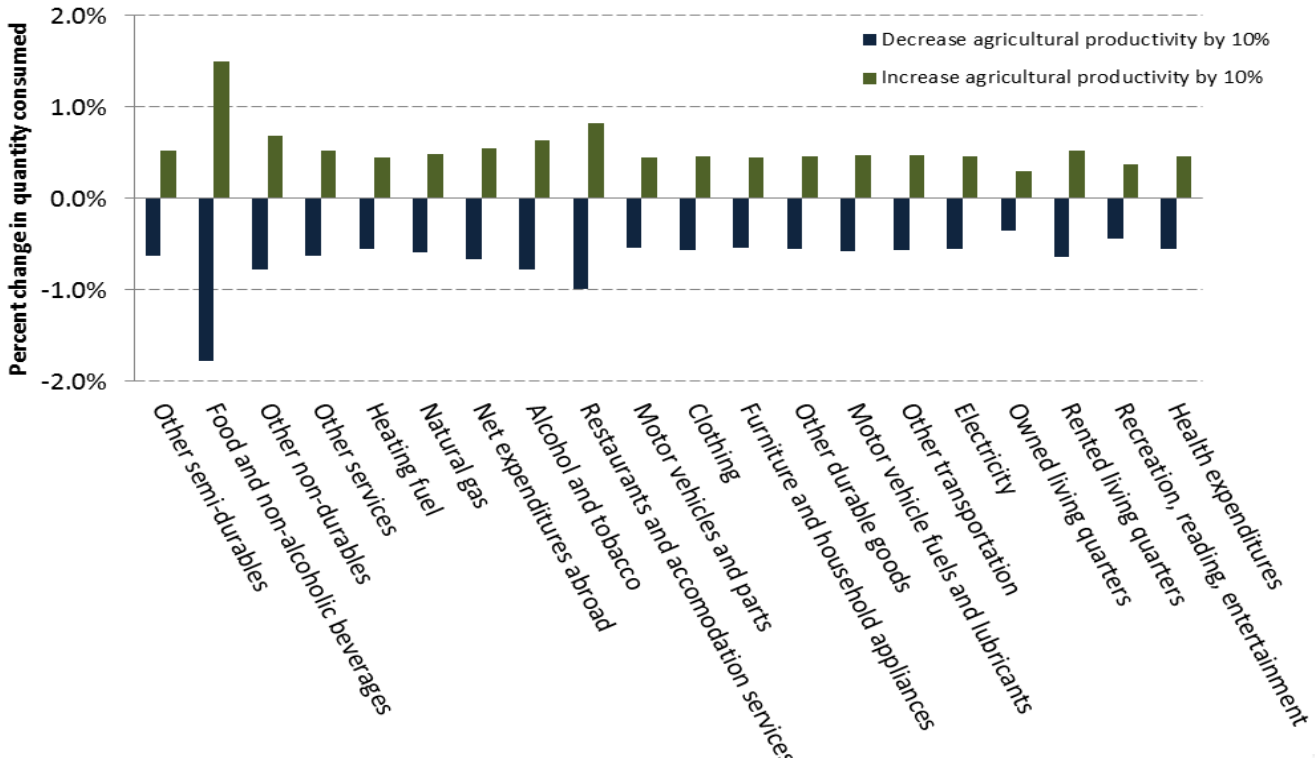
Figures 2 and 3 (and Tables 2 and 3 in Appendix 1) show the impact on consumer prices and quantity consumed, respectively, by subsector for each of the agricultural productivity scenarios. Table 1 shows the resulting impacts on industry revenues (in %).
The source data for the results presented in Figures 2 and 3 is detailed in Tables 1 and 2 in Appendix 1.

Figure 2: Price Impacts



Source: Sustainable Prosperity

Figure 3: Quantity impacts



Source: Sustainable Prosperity

Interpretation

Sustainable Prosperity used a computable general equilibrium (CGE) model to examine the impact on prices and consumption for the four scenarios (see text box on page 5 for details about the water scenarios). A CGE model is dynamic, and captures the reallocation of inputs between sectors and the corresponding effect on outputs of a given scenario. To determine how inputs (e.g. capital, labour, etc.) will be substituted within a sector and reallocated between sectors, it relies on income and price elasticities (behavioural response to prices) and transaction values (how many inputs various sectors use to create outputs).

From the results in Figures 2 and 3 (and Tables 2 and 3), there are several subsectors that are clearly more impacted than others for the scenarios we considered. Obviously the greatest impacts for the agricultural productivity scenarios are seen in the subsectors most reliant on the agricultural sector for inputs, namely food and non-alcoholic beverages and restaurants and accommodation services. The fall in agricultural productivity likely translates into a price increase for most agricultural outputs (i.e. grains, seeds and oils). Many sectors reliant on these inputs will just pass on costs to consumers. Few other sectors experience price impacts greater than 1%.

These results are discussed in more detail below.

Price Impacts

Food and non-alcoholic beverages would see a 4.4% price increase under a scenario where agricultural productivity falls by 10%. (It would see – in theory – a price decrease of 3.6% if agricultural productivity rose by 10%). Similarly, restaurants and accommodation

Table 1: Overall Revenue Impact on Industry (Price * Quantity)

SCENARIO	DECREASE AGRICULTURAL PRODUCTIVITY BY 10%	INCREASE AGRICULTURAL PRODUCTIVITY BY 10%
OTHER SEMI-DURABLES	-0.9%	0.8%
FOOD & NON-ALCOHOLIC BEVERAGES	2.5%	-2.15%
OTHER NON-DURABLES	-0.5%	0.3%
OTHER SERVICES	-0.9%	0.8%
HEATING FUEL	-1.1%	1.0%
NATURAL GAS	-1.1%	0.9%
NET EXPENDITURES ABROAD	-0.9%	0.7%
ALCOHOL & TOBACCO	-0.5%	0.4%
RESTAURANTS & ACCOMMODATION SERVICES	0.2%	-0.1%
MOTOR VEHICLES & PARTS	-1.2%	1.1%
CLOTHING	1.2%	1.0%
FURNITURE & HOUSEHOLD APPLIANCES	-1.1%	1.0%
OTHER DURABLE GOODS	-1.1%	1.0%
MOTOR VEHICLE FUELS & LUBRICANTS	-1.1%	1.0%
OTHER TRANSPORT	-1.2%	1.0%
ELECTRICITY	-1.2%	1.0%
OWNED LIVING QUARTERS	-1.8%	1.5%
RENTED LIVING QUARTERS	-0.9%	0.7%
RECREATION, READING & ENTERTAINMENT	-1.5%	1.3%
HEALTH	-1.1%	1.0%

Source: GreenChip

services would see a 1.2% price increase if agricultural productivity falls by 10%, because it also relies on food as a key input. In the food and beverage and restaurant sectors, the projected price increases could be beneficial, given that the prices rise more than quantity consumed falls. In this scenario producers could absorb increased profits, depending on the extent to which price increases match the increase in costs.

The other less intuitive impacts are the 1.4% fall in price for housing purchases and 1.1% fall in recreation prices if agricultural productivity fell by 10%. A fall in agricultural production and increase in food prices will ripple through the entire economy (since it accounts for 1.7% of GDP) and will affect income available for other sectors. This explains the fall in prices for non-food related goods (as income falls, so does demand, and therefore prices).

Quantity Impacts

Given that many sectors that face a rise in costs will pass these costs on, the corresponding impacts on consumer expenditures depend on the price elasticity for that sector. For example, food is considered to be an inelastic good, in that even as prices go up, demand will not fall as much as price increases. Because it is a necessity, there will always be a basic level of demand for food. This is visible in the results, as when food prices rises by 4.4%, consumption only falls by 1.8%, and not by the full amount of the price increase, leading to increased spending allocation to food. This is where the squeeze in consumer spending occurs. Even though the price increases for many sectors do not seem significant, there is a fairly uniform fall in consumption across the board as a reaction to increased prices in a few sectors. The sectors seeing the greatest decrease in consumption are restaurants and accommodation services (i.e. hotels), other non-durables (e.g. televisions and electronics), alcohol and tobacco, and net expenditures abroad (i.e. vacations).

These results support the general investment theory presented at the beginning of the paper, where the effect of climate change on the price level of sectors more directly impacted and vulnerable to environmental risks (such as agriculture to climate change) will trickle down and affect the rest of the economy in two ways. The first is through the effect on the overall economy of decreased output or increased prices in one or more sectors. Given the shared markets for inputs such as labour, capital and technology, all sectors and input markets will be impacted in some way (some may even benefit) as price changes induce inputs to be reallocated between sectors. The second is through the effect on household budgets. When consumers have to spend more money on certain goods (especially on basics such as food or electricity), they have fewer resources to spend elsewhere, such as on non-essentials.

Investment Implications

From an investment perspective, sectors will be affected by the combination of changes to market prices and quantity demanded. Table 3 shows that a decrease in productivity in the agricultural sector would actually raise sector revenues for food and non-alcoholic beverages (+2.5%) as well as restaurants and accommodation (+0.2%). All other sectors would experience negative revenue impacts, with the largest drops experienced by owned living quarters (-1.8%), recreation (-1.5%), and electricity, other transport and motor vehicles and parts (all -1.2%). Least affected among non-food related sectors were other non-durables (-0.5%) and other semi-durables, other services, net expenditures abroad and rented living quarters (all -0.9%).

While the percentage effects are relatively small, the more affected sectors are either more discretionary or larger budget items such as recreation, houses, cars and other durables. The less affected sectors are less discretionary non-durables and services.

Over and above changes to sector size in revenue terms, changes to profit margins are likely even more important to the prospective

profits investors may realize. While price changes inferred from our CGE model will contribute to margin changes, we can only infer changes to sector costs, the other half of the margin calculation. Beyond the obvious increases to food prices, we might expect a decline in agricultural productivity to increase, at the margin, costs to inputs such as fertilizer and labour as more of these inputs are required to keep a constant level of production. Energy inputs to agriculture may also be in higher demand, but this would likely be offset by reduced demand in discretionary sectors. On balance, although the agricultural sector enjoys a 4.4% increase in prices in a reduced-productivity scenario, as a commodity sector we would not expect margins to improve. And in downstream producers of food and beverages, margins may even decline in spite of price increases as cost increases are not fully passed on.

In general, from the perspective of investment "winners and losers", given an equal revenue impact, those sectors with the greater price drop will experience a greater drop in profitability. From the results of our CGE model, applying this logic, owned living quarters and recreation stand out as the most vulnerable. The vulnerability of recreation, as the most discretionary category, provides some confirmation of the risks to discretionary sectors of third-order effects of climate change and/or resource scarcity.