Consumer demand for ultra-processed

VS.

fresh and minimally processed foods

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Table of Contents

Executive Summary

Extensive research has used the NOVA system to classify foods according to the type of processing and to examine links with diet quality and health. The results paint a consistent picture: the healthiest diets are high in fresh and minimally processed foods such as fresh fruits and vegetables, and low in ultra-processed foods such as soft drinks, fruit drinks, industrially prepared cookies, sweets and snacks, and processed meats. The recently revised 2019 Canada's Food Guide (2019 CFG) defines a healthy eating pattern in very similar terms.

In 2019, the Lancet Commission on the global syndemic of obesity, undernutrition and climate change called on all countries to shift toward healthy and sustainable food systems based on fresh and minimally processed foods, mostly plant-based, to address both human and planetary health. However, the current high consumption of ultra-processed foods, as well as their massive production levels, is not just a problem for human and planetary health—it also affects the food system economy. Presently, little is known about the economic impact of consumer demand for healthy versus unhealthy foods on different sectors of the food system, specifically, food production, processing and distribution. In this report, we address the question: What are the economic consequences of shifting the Canadian diet towards one that is less processed? More specifically, this study compared the impact of consumer demand for selected healthy and unhealthy foods on farmers' revenues and, more generally, on the Canadian food system.

What did this study do?

We conducted a study to determine the impact of consumer spending on selected healthy versus unhealthy foods on Canadian farmers and the rest of the food system economy. Eleven commonly consumed food product categories (including fresh fruits and vegetables, fresh and frozen beef and veal, and processed meats) were categorized as healthy or unhealthy according to the type of processing and healthy eating recommendations in the 2019 CFG. In this report, "healthy foods" refer to fresh and minimally processed foods, whereas "unhealthy foods" refer to ultra-processed products. A macroeconomic input-output model was used to estimate how a dollar spent by the consumer in 2017 on the selected food products was distributed between different sectors of the Canadian food system. This was done to estimate the relative share of the food dollar and revenues generated by farmers and other food system sectors.

What did the study find?

- In Canada in 2017, demand for fresh and minimally processed foods was more financially beneficial for farmers than demand for ultra-processed products. The opposite was true for food processors.
- For every dollar spent by consumers on fresh vegetables, farmers generated 13 cents in revenues; in contrast, farmers generated only 1 cent for fruit and vegetable juices.
- Farmers received a share of revenues 3-to-8 times higher when fresh fruits, vegetables and potatoes were sold to consumers than when those same foods were sold to the food processing sector as ingredients for ultra-processed products (e.g., fruit and vegetable juices, snack food products).

What do the findings mean?

Results showed that in 2017, Canadian farmers received a higher share of the food dollar and generated higher revenues when consumers bought healthy foods than when they bought unhealthy foods. In contrast, the food processing industry received a higher share of the food dollar and higher revenues for unhealthy, ultra-processed foods. This evidence points to the potential beneficial impact of transforming the Canadian food system toward one that fosters a fresh and minimally processed diet. Developing policies to support, promote and protect the production and consumption of fresh and minimally processed foods is critical for supporting the agricultural sector and addressing the ongoing chronic disease crisis in Canada and globally. Such policies would benefit not only farmers, but also people's health and the health of the planet. Among these, front-of-package nutrition labelling and restrictions on the marketing of unhealthy foods to children are necessary policies to reduce consumer demand for ultra-processed foods and drinks.

Introduction

Diets are inextricably linked to the nature and quality of food systems.

Our current Canadian food system needs a profound overhaul to offer more healthy and sustainable foods for all Canadians. Indeed, the current Canadian diet does not promote good health. Nearly half of all calories consumed by Canadians come from ultra-processed foods and drink products (Polsky et al., 2020; Nardocci et al., 2019). Ultra-processed products are industrial formulations made of refined food substances and cosmetic additives, which are used to create durable, appealing and ready-to-eat or ready-to-heat products (Monteiro et al., 2019a). They include soft drinks, packaged snacks, fast foods and frozen dinners. Consuming a diet high in ultra-processed products is associated with higher prevalence of non-communicable diseases, including type 2 diabetes, hypertension, cardiovascular disease and obesity (Monteiro et al., 2018; Monteiro et al., 2019b; Nardocci et al., 2021).

To address the problem of modern diets, the recent Lancet Commission on the global syndemic of obesity, undernutrition and climate change has called for a global shift toward healthy and sustainable food systems, and for adopting diets that are less processed and more plant-based (Swinburn et al., 2019). The Commission also recognized the key role that public policies must play in such a transformation. The recently revised 2019 Canada's Food Guide invites health professionals and citizens to embark on such a shift for health and environmental reasons, recommending cooking, preferring fresh or minimally processed foods such as fruits and vegetables, and avoiding highly processed foods (i.e., those that contribute excess sodium, free sugars or saturated fat) such as soft drinks and packaged snacks (Government of Canada 2019a; Government of Canada, 2019b).

A major shift in our food system,

however, requires that all food policies be coherently aligned to promote healthy and sustainable diets. In Canada, there have been few government actions to consider health in all food policies and to conduct health impact assessments in non-food policies (Vanderlee et al., 2019). More specifically, the current agricultural policies related to food production do not include a nutritional perspective, but focus mainly on productivity and profit (INSPQ, 2011). This is because agricultural, food- and nutrition-related policies are rarely designed together. A recent Australian study pointed out that actors from multiple government sectors, each with different interests and positions, have different ways of framing nutritional problems and solutions (Baker et al., 2019).

A lack of coherence in public policies has important health, environmental and economic consequences for Canadians. Indeed, in addition to the negative impact on health, the increased consumption of ultra-processed foods, as well as their overproduction, affect the food system economy (Silventoinen et al., 2004). A study conducted by the United States Department of Agriculture estimated the share of the typical food dollar that went to farmers. This study found that between 1993 and 2008, the farm share of all foods purchased for home consumption remained fairly constant, varying between 22.1% and 24.6% (Canning, 2011, p.10). In contrast, the farm share of away-from-home food expenditures (including food purchased at

restaurants and food supplied in domestic institutions, like school lunches) declined from 10.5% to 4.7% (Canning, 2011). In 2008, U.S. farmers received only 4.7% of total away-from-home food expenditures, while 95.3% went to the food processing and other sectors, including distribution and transport (Canning, 2011). In Canada, the distribution of a dollar spent on food by consumers between farmers and other sectors of the food system has not yet been examined.

Canadian farmers can sell their products to be marketed as fresh foods or they can sell them to the food processing industry to be used in the manufacture of foods of various types, including minimally processed foods and ultra-processed products. These scenarios are not equally beneficial for farmers. In general, we would expect a greater fraction of the consumer dollar to go to farmers when they market their products as fresh than when they sell their products to the food processing industry. This is because food processing is likely to retain more of the consumer dollar, leaving less for the farmer. This notion, however, needs to be verified and quantified.

In order to inform the Canadian food system shift towards healthier and more sustainable diets, this study addresses the following question: **How much revenue is made by Canadian farmers when Canadians spend a given amount of money on various healthy and unhealthy foods?** Do farmers earn more when Canadians buy fresh produce like fresh fruits and vegetables, or when they buy ultra-processed products like fruit juices and salty snacks? To answer this question, we track a dollar spent on food by Canadian consumers and estimate the share of that dollar that goes to farmers and the share that goes to other food system sectors. To do so, we use an economic model of all transactions between all industry actors, including farmers, processors, transport and storage, and trade intermediaries.

Methods

Overview of the Analytic Approach

The objective of the study was to compare the impact of Canadian consumer demand (i.e., the dollar amount spent by consumers) for various foods on farmers' revenues and, more generally, on the Canadian food system economy. More specifically, this study asked the following questions: How much revenue do farmers make when Canadians spend their money on foods of different processing types and nutritional value? Do farmers stand to gain higher revenues when Canadians buy fresh and minimally processed foods like fresh fruits and vegetables, or when they purchase ultra-processed products like fruit and vegetable juices, commercially prepared cookies and snack foods?

Given the complexity of our food system, we cannot be content with examining who gets the consumer dollar initially. This is because consumer food purchases cascade through the economy from the consumer (i.e., ultimate buyer) to first-round suppliers (e.g., grocery stores), then to suppliers of these suppliers (i.e., second-round suppliers such as farmers supplying the grocery store), and further on to the third, fourth and subsequent rounds of suppliers. To fully consider the multiple pathways followed by the consumer dollar as it cascades through the economy, we need to examine the successive rounds of demand and supply to determine who ultimately receives which share of the original consumer dollar. To do this, an economic model is required. We chose to use an input-output model (IOM), which is particularly well suited for this study's objectives.

We created an IOM that represents the monetary transactions between Canadian industries, including those that make up the farming sector (i.e., crop production, greenhouse, nursery and floriculture production, and animal production), the food processing, distribution, transport and storage, and other sectors. Our model allows us to compute the revenues generated in farming, both directly and indirectly, from any given pattern of consumer food spending. **Here, the expression "revenue generated" refers to the concept of "value added."** Value added can be broken down into revenues for the farmer and other components such as wages and salaries. Value added is the economic concept underlying the gross domestic product (GDP). The GDP is the grand total of value added generated in all industries within a given time period, in a given country.

The IOM answers such questions as: What if consumers were to demand (i.e., purchase) $1 (or $100 or $1,000) worth of fresh vegetables? A run of the model to compute the answer to such "what if" questions is called a "simulation" of a "final demand shock." For the purposes of this study, we simulated the impact of one consumer dollar of demand for various food products categorized as healthy or unhealthy based on prior work using the NOVA classification and the 2019 CFG (see Table 1).

Our IOM is very detailed. It has 240 industries and 492 product categories. For the purposes of this study, the 240 industries were grouped into five sectors (see Table 2 for details):

1. Agricultural and livestock production (referred to as "farmers" in this report);
2. Food processing;
3. Distribution (wholesale and retail);
4. Transport and storage;
5. Other (a residual group that includes all other industries).

Data Sources and Data Preparation

Supply and Use Tables for the Input-Output Model

For this study, the input-output table underlying the IOM was built using Statistics Canada's 2017 national Supply and Use Tables (SUTs). These tables are produced every year and provide a detailed snapshot of all economic activity taking place in a geographic region. They are a powerful analytic tool that presents the structure of an economy, as well as the interlinkages among various economic actors. These tables allow us to trace the flow of goods and services between different industrial sectors from their production or import to intermediate use, through to final consumption by consumers (Institut de la Statistique du Québec, 2017; Statistics Canada, 2021).

Defining Healthy and Unhealthy Foods

We selected eleven food categories available in Statistics Canada's SUTs and classified them as either healthy or unhealthy. This classification drew on the NOVA system, which classifies foods according to the type of food processing (Monteiro et al., 2019a), and healthy eating recommendations in the 2019 Canada's Food Guide (Government of Canada, 2019a; Government of Canada, 2019b). These recommendations include eating plenty of vegetables and fruits, whole grains and protein foods; making water the drink of choice; and limiting highly processed foods such as sugary drinks, processed meats, chocolate and candies, and bakery products like muffins and cakes.

The selected food categories for this study and their classification, along with examples, are summarized in Table 1. In this study, **healthy foods** were categorized as the following fresh or minimally processed foods: fresh fruit and nuts; fresh vegetables; fresh potatoes; and fresh and frozen beef, veal, pork and poultry. **Unhealthy** foods were the following ultra-processed product categories: fruit and vegetable juices; preserved and frozen foods; cookies, crackers and baked sweet goods; snack food products; and processed meat products.

Table 1. Food categories classified according to NOVA and the North American Products Classification System (NAPCS), Canada 2017, Version 2.0[a]

NOVA GROUP 1: FRESH OR MINIMALLY PROCESSED FOODS	
FOOD CATEGORY AND NAPCS CODE	**DESCRIPTION & EXAMPLES**
Fresh fruit and nuts (11411)	Fresh fruit, including apples, pears, plums, grapes, berries, oranges, lemons and bananas; nuts, such as peanuts and hazelnuts.
Fresh vegetables (except potatoes and pulse crops) (11422)	Includes fresh root type vegetables, fresh bulb type vegetables, fresh leaf and stem type vegetables, fresh mushrooms, fresh melons, fresh fruit type vegetables, green leguminous vegetables. Examples include carrots, radishes, lettuce, onions, beets, asparagus, spinach, cabbage, celery, cantaloupes, watermelons, eggplant, squash, peppers, beans, broccoli, cauliflower.
Fresh potatoes (11421)	Fresh or chilled potatoes.
Fresh and frozen beef and veal (17211)	Fresh and frozen cuts of beef and veal, including ground beef and patties.
Fresh and frozen pork (17212)	Fresh and frozen pork, including pork back ribs, bellies and loins.
Fresh and frozen poultry of all types (17213)	Fresh and frozen poultry of all types (chicken, turkey and other fowl).

NOVA GROUP 4: ULTRA-PROCESSED PRODUCTS	
FOOD CATEGORY AND NAPCS CODE	**DESCRIPTION & EXAMPLES**
Frozen, fresh and canned fruit and vegetable juices (19211)	Frozen, fresh[b], from concentrate or canned fruit and vegetable juices, including tomato, carrot, grape, apple and orange juices.
Preserved and frozen foods (18351 and 18352)[c]	Preserved foods include canned soups and stews, bouillons, preserved jams and jellies, ketchup, canned tomato-based sauces and pastes, pickled vegetables, canned vegetables, canned fruit, and dried fruit, vegetable, soup mixes and bouillon. Frozen foods include frozen chicken dinners and pies, frozen pizza, frozen pasta, frozen veggie burgers, frozen pre-cooked waffles, frozen vegetables (plain, or in sauces) and frozen fruit.
Cookies, crackers and baked sweet goods (18314)	Includes cookies and crackers, baked desserts (e.g., dessert pies, doughnuts, pastries and soft cakes).
Snack food products (18331)	Includes potato chips, processed nuts and seeds, corn-based snacks (e.g., corn chips, nacho chips), hard pretzels.
Processed meat products, other meats, and animal by-products (17215)	Processed, either dressed, cut, or chilled meat products, other meats, and animal by-product, including sausages, ham, bacon and canned meats.

a. North American Product Classification System (NAPCS), Canada, 2017, Version 2.0. Statistics Canada, 2018. Available at: https://www23.statcan.gc.ca/imdb/p3VD.pl?Function=getVD&TVD=1196268.

b. Freshly squeezed fruit and vegetable juices with no added sugars are classified as minimally processed beverages according to the NOVA classification. However, the NAPCS does not allow the disaggregation of these beverages from ultra-processed types (e.g., fruit drinks and juices with added sugars and other additives). Therefore, this analysis classified all juices and drinks as "unhealthy" because (a) the consumption levels of freshly squeezed juices in Canada are not known; (b) industrially prepared ultra-processed juices and drinks dominate the consumer food market, and (c) the 2019 Canada's Food Guide recommends water as the drink of choice;

c. The category of "preserved and frozen foods" contains both minimally processed foods (e.g., frozen fruit), processed foods (e.g., canned vegetables) and ultra-processed products (e.g., frozen dinners), as defined by NOVA. However, considering the dominance of ultra-processed foods in this category, all foods in this category were classified as ultra-processed for this study.

Table 2. Description of food system sectors and their suppliers, adapted from the North American Industry Classification System (NAICS)[a], Canada, 2017

SECTOR	DESCRIPTION
Agricultural and livestock production (referred to as "farmers" in this report)	Crop production; Greenhouse, nursery and floriculture production (except cannabis); Animal production; Aquaculture, Fishing, hunting and trapping.
Food processing	Sugar and confectionery product manufacturing; Fruit and vegetable preserving and specialty food manufacturing; Dairy product manufacturing; Meat product manufacturing; Seafood product preparation and packaging; Bakeries and tortilla manufacturing; Other food manufacturing; Soft drink and ice manufacturing; Breweries, wineries and distilleries.
Distribution (wholesale and retail)	Farm product merchant wholesalers; Food, beverage and tobacco merchant wholesalers; Miscellaneous merchant wholesalers; Food and beverage stores; General merchandise stores; Miscellaneous store retailers (except cannabis); Gasoline stations.
Transport and storage	Air transportation; Rail transportation; Water transportation; Truck transportation; Warehousing and storage.
Other	Support activities for crop and animal production; Support activities for forestry; Oil and gas extraction (except oil sands); Oil sands extraction; Support activities for oil and gas extraction; Support activities for mining; Electric power generation, transmission and distribution; Natural gas distribution; Water, sewage and other systems; Residential building construction; etc.

a. North American Industry Classification System (NAICS), Canada, 2017. Available at: https://www23.statcan.gc.ca/imdb/p3VD.pl?Function=getVD&TVD=307532.

Operating the Model

The following section provides an overview of how to the IOM was operated in this study. The detailed model and mathematical calculations used in the model are presented in Appendices 1 and 2.

The model built for this study is a commodity by industry IOM, similar to the model used by the Institut de la Statistique du Québec (2017) as the Quebec intersectoral model. The model considers the production of several goods and services within a given industrial sector (e.g., farmers grow both fruits and vegetables), and the fact that a given set of goods may be supplied by more than one industry (e.g., fruits are supplied both by the crop production industry and by the greenhouse, nursery and floriculture industry). As mentioned above, the IOM is used to simulate the impact of a "final demand shock" on the food system economy (or, less dramatically, a change in final demand). Final demand is defined as all "transactions that involve purchases of produced goods and services produced for final uses" (Statistics Canada, 2019) and includes the total dollar amount spent by the consumer on a particular product in a given time period. Henceforth in this report, we refer to final demand for selected foods as "dollar spent" on food by consumers.

Preparing the model – The first step in running a simulation is to specify the final demand shock the impact of which we wish to simulate. In this study, every simulation models the impact of a $1 hypothetical increase in final consumer demand for a given food product (e.g., fresh vegetables). Before solving the IOM, we must calculate how much of the food dollar spent by consumers gets into production. To do so, we first need to subtract taxes on products (e.g., GST) from the food dollar, to calculate the proportion of that dollar that is paid to suppliers. For example, in 2017, for every $100 spent by consumers on fresh vegetables, $0.007 (i.e., 0.7 cents) went to taxes, and the remaining $99.993 went to suppliers.

However, the entire after-tax amount spent by consumers on fresh vegetables does not go to fresh vegetable suppliers – some of it pays for the retailers' and the wholesalers' trade margins, and for transportation and storage costs. Therefore, we must redistribute the consumer dollar between final demand for fresh vegetables and the various applicable margins.

Next, we calculate how much of the supply of each product comes from local producers and how much comes from imports. For example, in 2017, for every $100 spent by consumers on fresh vegetables, a quarter came from imports ($24.93), and three quarters went to local production ($75.06). Because this study focuses on Canadian farmers, we only consider money that went into local production.

Finally, we calculate how the money that goes into local production is distributed between Canadian industries. For example, in 2017, for each $75.06 supplied by Canadian industries to respond to a $100 consumer demand for fresh vegetables, $0.04 went to the food processing sector, $33.09 to distribution, $2.91 to transport and storage, and $2.89 to other sectors, leaving $35.76 for agriculture and livestock production (i.e., farmers).

Running the model – At this stage, the consumer demand for fresh vegetables has been parsed into taxes on products, imports and supplies by Canadian producers. This is the information that is fed into the model to run the simulation. As stated earlier, our IOM allows us to compute the revenues generated in farming and other industries, both directly and indirectly, by that final demand for selected foods (e.g., fresh vegetables). More precisely, the model calculates how much value added is created by each industry. What we call "value added" is the net contribution to production of a given industry, after intermediate inputs supplied by other producers have been deducted from the value of its production (see Text Box 1 for an explanation of "value added").

BOX 1. EXPLAINING "VALUE ADDED"

The concept of "value added" helps to avoid double counting. For example, the money that goes to a baker for a loaf of bread also includes the money paid by the baker for the flour used to bake the bread (and other ingredients bought from other industries – these transactions are called "intermediate demand"). In this example, summing the money paid to the baker and the money paid to the miller would count the value of the flour twice. For this reason, summing the *value of production* across industries is not a valid measure of total production in the economy. On the other hand, summing the value added across industries adds up to net production and yields a valid measure of the economy's total production. And because the model calculates the value added of each industry, it also gives each industry's share in the economy's total production.

Finally, the value added of each industry can be broken down into its components. In the case of agriculture, the model provides a breakdown of the value added between farmers' revenues and other components: wages and salaries paid to employees; employers' social contributions; and taxes minus subsidies on production. Farmers' revenues are estimated as the sum of gross mixed income and gross operating surplus. Gross operating surplus can be interpreted as the revenues of farms incorporated as companies, while gross mixed income is a combination of the revenues of unincorporated farms and the owners' work compensation.

As an illustration of this study's methodological approach, Figure 1 shows how the value added generated by a dollar spent on fresh vegetables in 2017 was distributed between farmers and other sectors of the Canadian food system. (Detailed data for Figure 1 are found in Appendix 3; analogous results for selected healthy and unhealthy foods are shown in Figure 3.) This example illustrates the breakdown of this food dollar into different components. For every dollar spent on fresh vegetables, 34 cents went to imports[1], 1 cent to taxes, and the rest to Canadian industries: 21 cents to the distribution sector, 2 cents to transport and storage, 23 cents to "other" sectors, less than 1 cent to food processing and 19 cents to farming. Within the amount going to farmers, 13 cents were generated as farmers' revenues and the remaining 6 cents as other value added generated in farming.

1 NOTE: The 34 cents going to imports includes both *direct* imports of fresh vegetables and any *indirect* imports generated at various stages in the economic process. In contrast, the amount of $24.93 of imports for $100 spent by consumers, indicated in the "*Preparing the model*" section above, includes only *direct* imports of fresh vegetables (see Appendix 1 for a more complete explanation).

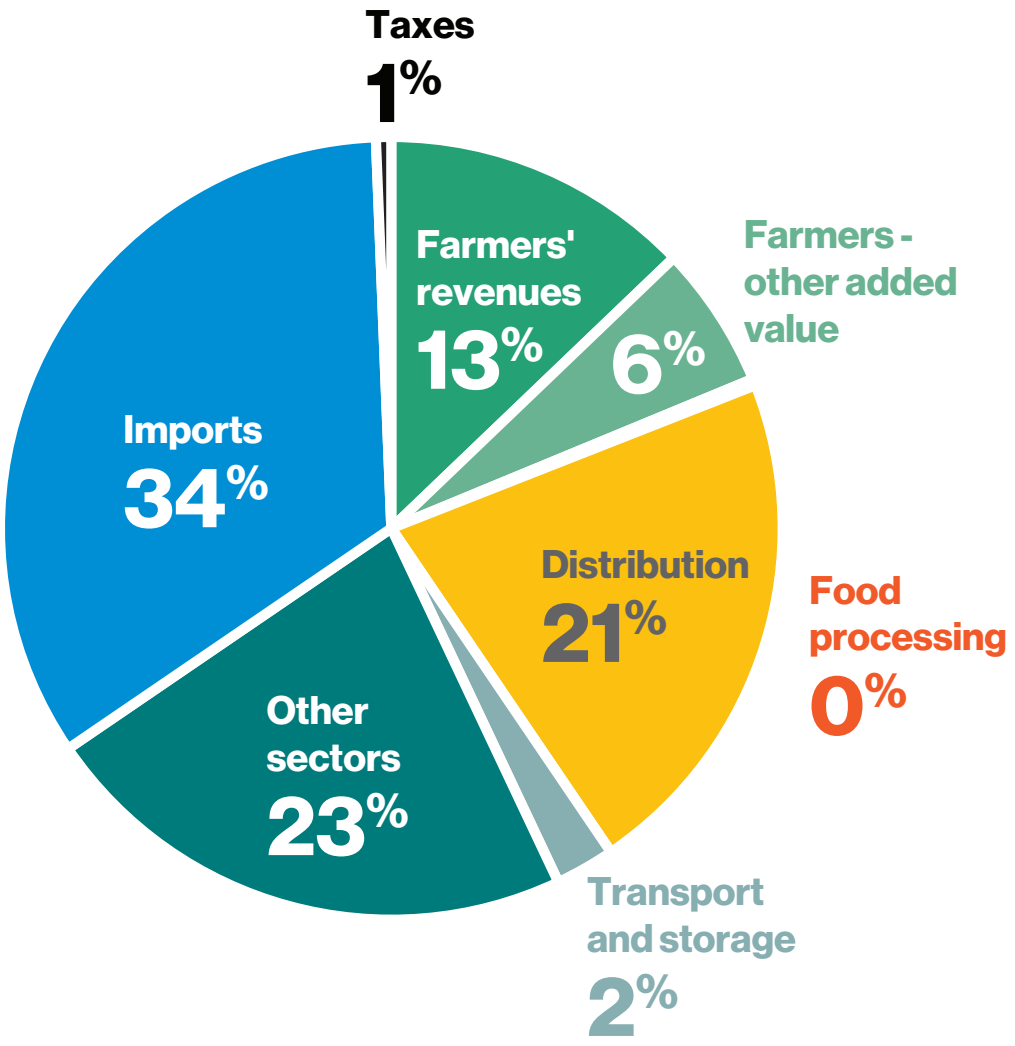


Figure 1. Distribution of the impact of $1 spent by consumers on fresh vegetables between taxes, imports and value added generated by Canadian producers, 2017.

Results

Results are presented in three parts. First, to set the context, we describe the initial distribution of one dollar spent in 2017 on selected healthy and unhealthy foods between local production, imports, and taxes in Canada. Second, we describe and compare the distribution of the impact of one dollar spent by consumers on the selected foods between taxes, imports and value added generated by Canadian producers. Third, we estimate and compare revenues generated by farmers and other food system sectors for the selected healthy and unhealthy foods. Readers can find the full set of results in Appendices 3 and 4.

i) Local Production, Imports and Taxes on Foods

Figure 2 shows the initial (first-round) distribution (%) of one dollar spent in 2017 by consumers on selected foods between local producers, imports and taxes. This is the result of the first step (see "*Preparing the Model*" section above), where we determine how much of the CAD $1 final demand is initially used to pay taxes (e.g., GST) on products and how much is spent on imports; the rest is the amount of final demand that is directly supplied by Canadian producers.

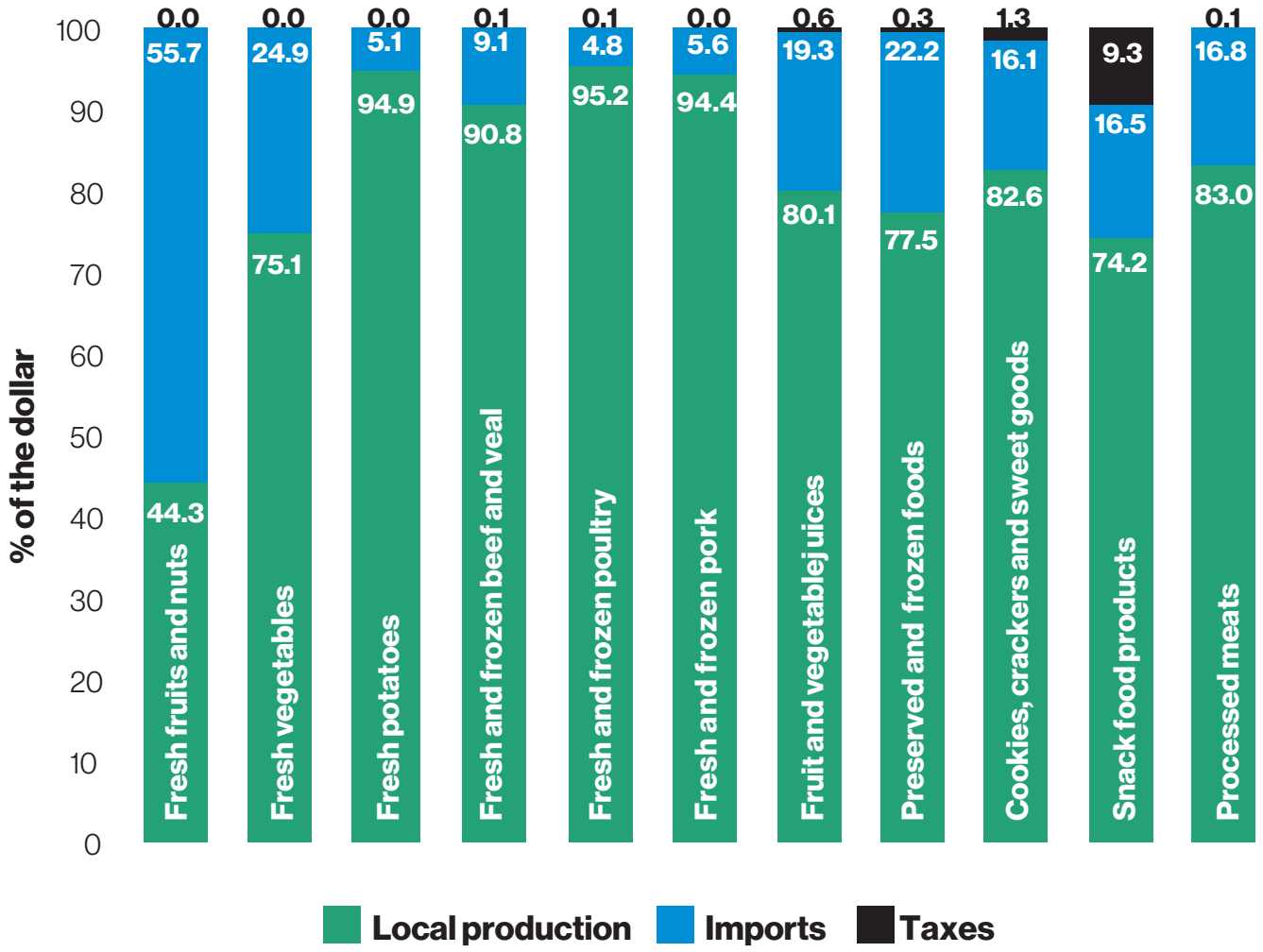


Figure 2. Initial (first-round) distribution of CAD $1 of final demand for selected foods between local production, imports and taxes, 2017.

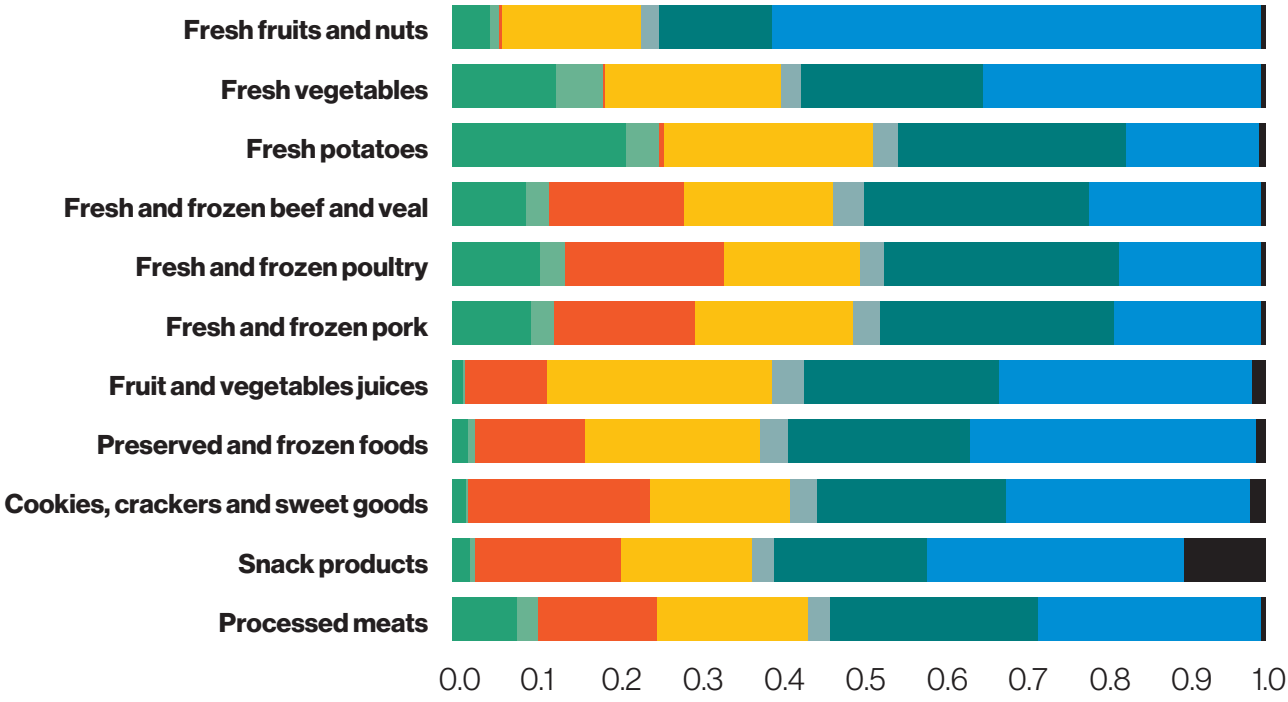
As shown in Figure 2, for every dollar spent on fresh potatoes and fresh or frozen beef, veal, pork and poultry, more than 90% went to Canadian local production, and less than 10% went to imports. For every dollar spent on cookies, crackers and sweet goods, snack food products, and processed meat products, between 74% and 83% went to local producers versus less than 20% to imports. For fruit and vegetable juices, approximately 80% of the food dollar went to local production and 20% to imports. For fresh vegetables, 75% of the food dollar went to local production versus 25% to imports, whereas for fresh fruits and nuts, only 44% went to local producers, while 56% went to imports. As expected, taxes were higher for ultra-processed foods (snack food products; cookies, crackers and sweet goods) than for fresh produce, for which taxes were less than 0.1%.

ii) Farmers' Share of the Canadian Food Dollar

Figure 3 shows the distribution of the impact of $1 spent on selected healthy and unhealthy foods in 2017 between taxes, imports and value added generated by farmers and other sectors of the Canadian food system. (Detailed data for Figure 3 are available in Appendix 3.) For every dollar spent by consumers on fresh potatoes, farmers generated 21 cents in revenues. Farmers received 13 cents of every dollar spent on fresh vegetables, and 5 cents for fresh fruits and nuts.

Farmers generated lower revenues when consumers bought more processed foods, including preserved and frozen foods (2 cents), and even less for fruit and vegetable juices (1 cent). For other ultra-processed foods, including cookies, crackers and sweet goods, and snack food products, farmers generated 2 cents for every dollar. For every dollar spent on animal-based foods, farmers generated 9 cents for fresh beef and veal, 10 cents for pork, and 11 cents for poultry. They generated somewhat lower revenues for processed meat products, receiving 8 cents of every dollar spent by consumers.

Figure 3 also shows the revenues generated by other food system sectors for every dollar spent by consumers on the selected foods. Food processors generated between 10 cents and 22 cents for every dollar spent on ultra-processed foods such as fruit and vegetable juices and cookies, crackers and sweet goods. In contrast, the processing sector generated negligible amounts for a dollar spent on fresh produce, namely, fresh vegetables, fresh potatoes, and fruits and nuts. For animal products, food processors generated revenues between 15 cents and 20 cents for every dollar spent on these foods. The distribution and "other" food system sectors also drew an important share of the dollar for all food categories in this study.



	Processed meats	Snack products	Cookies, crackers and sweet goods	Preserved and frozen foods	Fruit and vegetables juices	Fresh and frozen pork	Fresh and frozen poultry	Fresh and frozen beef and veal	Fresh potatoes	Fresh vegetables	Fresh fruits and nuts
Farmers' revenues	0.08	0.02	0.02	0.02	0.01	0.10	0.11	0.09	0.21	0.13	0.05
Farmers-other added value	0.02	0.01	0.00	0.01	0.00	0.03	0.03	0.03	0.04	0.06	0.01
Food processing	0.15	0.18	0.22	0.14	0.10	0.17	0.20	0.17	0.00	0.00	0.00
Distribution	0.19	0.16	0.17	0.22	0.28	0.19	0.17	0.18	0.26	0.21	0.17
Transport and storage	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.04	0.03	0.02	0.02
Other sectors	0.25	0.19	0.23	0.22	0.24	0.29	0.29	0.28	0.28	0.22	0.14
Imports	0.27	0.32	0.30	0.35	0.31	0.18	0.18	0.21	0.17	0.34	0.60
Taxes	0.01	0.10	0.02	0.01	0.02	0.00	0.00	0.01	0.01	0.01	0.01

Figure 3. Distribution of the impact of $1 spent by Canadian consumers on selected foods between taxes, imports and value added generated by Canadian producers, 2017.

In summary, consumer demand for fresh fruits, nuts and vegetables, as well as fresh potatoes, generated higher revenues for farmers than demand for fruit and vegetable juices, cookies, crackers and sweet goods, and snack products. On the other hand, the food processing sector received a higher share of a dollar spent on the manufacture of fruit and vegetable juices, snack foods, and cookies, crackers and sweet goods. Notably, the distribution sector also received a very large share of the food dollar for all food categories examined (ranging from 16 to 28 cents).

The differences highlighted above are explained by the necessary costs incurred in the manufacture of ultra-processed foods. However, from a nutrition perspective, our results suggest that farmers generated higher revenues when consumers bought healthy foods, compared with unhealthy foods. In contrast, the food processing sector received a larger share of the food dollar when consumers purchased certain unhealthy products (i.e., cookies, crackers and sweet goods, and snack products). However, food processors also generated a large share of the food dollar from preserved and frozen foods, which is a heterogenous category that includes foods recommended as part of a healthy eating pattern (e.g., frozen fruits and vegetables). Finally, there was little variation in farmers' revenues from various types of meat, whether minimally processed or ultra-processed.

iii) Comparing Farmers' revenues to Other Food System sectors

Table 3 presents the share (%) of revenues received by farmers and other food system sectors in response to demand for selected healthy and unhealthy foods purchased by Canadian consumers in 2017. Here we estimate "revenues" as the sum of mixed income and gross operating surplus. (Detailed data for Table 3 can be found in Appendix 4; see second-last row in tables.) Farmers received a relatively high share of the revenues generated in response to demand for fresh potatoes and fresh vegetables: 50.4% and 43.1%, respectively, for each consumer dollar spent. They also received close to a third (29.6%) of all revenues generated in response to demand for fresh fruits and nuts. In contrast, farmers' share of the revenues was much lower for preserved and frozen foods, at 8.4%, and even lower for fruit and vegetable juices, at 5.3%. Farmers' share of the revenues was also relatively low for other unhealthy, ultra-processed foods such as cookies, crackers and sweet goods (6.4% of all revenues) and snack products (9.9%). For animal-based foods, farmers received over a quarter of total revenues (between 26.3% and 27.0%), regardless of the type of meat.

In contrast to farmers, the processing industry received a much higher share of the revenues for unhealthy, ultra-processed commodities such as fruit and vegetable juices (15.2%), cookies, crackers and sweet goods (31.3%), and snack products (33.4%). Processors also drew a relatively high share of the revenues for preserved and frozen foods (23.4%).

Figure 4 replicates data presented in Table 3 for *plant-based foods only* to facilitate a comparison of different consumer food choices using comparable foods. As shown in Figure 4, the more processed the plant-based foods, the lower the share of revenues received by farmers and the higher the share of revenues received by the food processing sector. Indeed, farmers received a share of revenues three-to-eight times higher when marketing fresh produce to consumers, compared to selling those same foods to the food processing industry as ingredients for ultra-processed products (e.g., fruit and vegetable juices). For example, farmers received 29.6% and 50.4% of all revenues for fresh fruits and nuts, and fresh potatoes, respectively, versus 5.3% of revenues for fruit and vegetable juices and 9.9% for snack products.

Table 3. Share (%) of the revenues received by farmers and other food system sectors for selected healthy and unhealthy foods purchased by Canadian consumers, 2017.

		Farmers	Processing	Distribution	Transport & storage	Other	Total
Healthy	Fresh fruits and nuts	29.6	0.6	29.6	5.1	35.1	100
	Fresh vegetables	43.1	0.4	20.4	3.3	32.8	100
	Fresh potatoes	50.4	0.4	17.6	3.1	28.5	100
	Fresh and frozen beef	27.0	19.6	14.1	4.5	34.8	100
	Fresh and frozen pork	27.0	19.5	15.3	3.8	34.4	100
	Fresh and frozen poultry	26.4	21.3	12.5	3.3	33.5	100
Unhealthy	Fruit and vegetable juices	5.3	15.2	35.8	5.9	37.7	100
	Preserved and frozen foods	8.4	23.4	26.9	4.8	36.4	100
	Cookies, crackers and sweets	6.4	31.3	20.4	5.0	36.9	100
	Snack products	9.9	33.4	20.3	4.3	32.1	100
	Processed meat products	26.3	19.0	16.6	3.3	34.8	100

The share of the revenues received by farmers versus processors appeared more balanced for animal-based foods (Table 3) than for plant-based foods (Figure 4). Indeed, regardless of the type of meat, farmers received between 26.3% and 27.0% of all revenues, whereas food processors received between 19.0% and 21.3% (Table 3). It is noteworthy that for all food categories examined in this study, the distribution sector received a relatively high share of the revenues (between 12.5% and 35.8%), as did "other" sectors (between 28.5% and 37.7%), which comprise the electricity and oil production sectors.

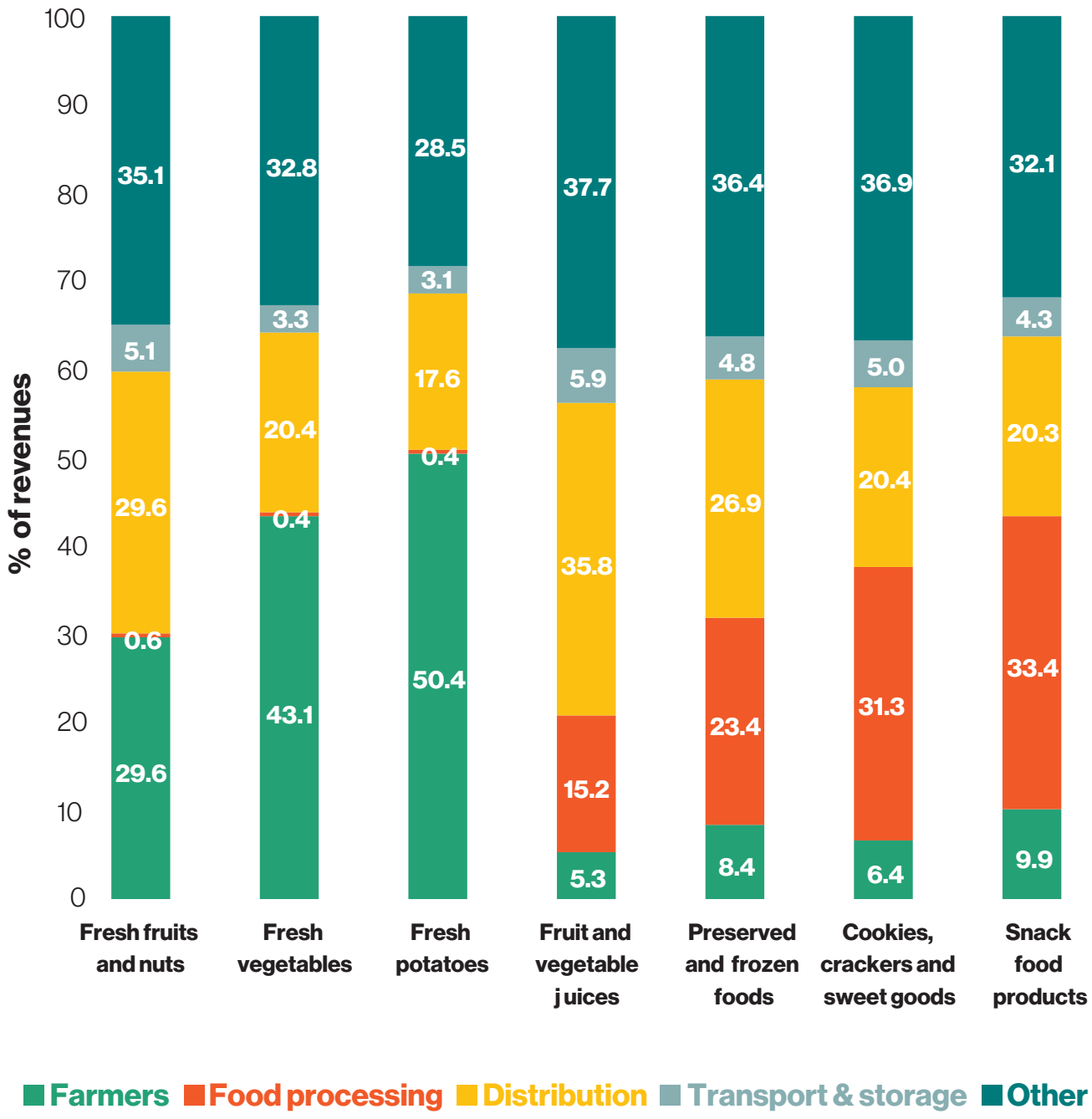


Figure 4. Share (%) of the revenues received by farmers and other food system sectors for selected plant-based foods purchased by Canadian consumers, 2017.

Discussion

Farmers receive a small share of revenues in the current food system.

This study examined how consumer spending on selected healthy and unhealthy foods impacted farmers' revenues and the revenues of other Canadian food system sectors in 2017. The results reflect a complex system that exists between farmers and consumers (Committee on a Framework for Assessing the Health, Environmental, and Social Effects of the Food System, et al., 2015). Currently, a significant part of the value added in food production is generated in the processing and distribution sectors – more so than in agricultural production. Based on a different but comparable methodology, a 2021 U.S. study showed that on average, farmers received only 27% of consumer spending on food consumed at home and even less for food consumed away from home (Yi et al., 2021). In the current study, we estimate that in 2017, farmers received between 5.3% and 50.4% of total revenues for various healthy and unhealthy foods purchased by consumers. However, farmers' revenues varied greatly between foods of different processing types.

Consumer demand for ultra-processed foods negatively impacts farmers' revenues.

This study showed that farmers drew a significant share of the total revenues when Canadians bought fresh or minimally processed foods such as fresh vegetables, fresh potatoes, fresh fruits and nuts, as well as fresh and frozen meat and poultry. Among fresh and minimally processed foods, vegetables and potatoes generated higher revenues for the agricultural sector. In contrast, farmers received much lower revenues when Canadians bought ultra-processed foods such as juices, crackers, cookies and other baked sweet goods, and snack food products. In fact, farmers received revenue shares three-to-eight times higher when fresh fruits and nuts, vegetables and potatoes were sold to consumers than when those same foods were sold to the food processing industry as ingredients for ultra-processed products.

The opposite pattern was observed for the food processing sector. Ultra-processed products were the most profitable because they generated much higher revenues than fresh produce. According to Agriculture Canada (2021), the food and beverage processing industry is the largest buyer of agricultural products. Thus, by adding "value" to fresh foods, the food processing industry adds a cost to the final product. However, this cost does not reach farmers because food processors derive most of the revenues (Canning, 2011). Indeed, for each unhealthy food, the value added will be greater for the processing industry than for farmers, partly because of the additional costs involved in the processing of fresh and minimally processed foods purchased

from farmers. This is the case for fruit and vegetable juices, cookies, crackers and baked sweet goods, as well as snack foods. Thus, the mass production of such unhealthy foods significantly reduces farmers' revenues because farmers generate only a small share of the total revenues for these products. Considering that nearly half of all daily calories consumed by Canadians come from ultra-processed foods (Polsky et al., 2020), it is clear that the current high demand for these products generates much lower revenues for farmers compared to revenues that would be generated by a similar demand for healthy foods.

The shift from consumption of fresh and minimally processed foods to consumption of ultra-processed foods has been harmful for Canadians' diet quality and health, as well as planetary health.

Throughout the 20th century, there have been major changes in Canadians' food spending patterns. From 1938 to 2011, Canadians reduced their time spent cooking and decreased spending on fresh and minimally processed foods (Moubarac et al., 2014). Such foods have been replaced with pre-prepared and ready-to-eat ultra-processed products, including soft drinks and juices, packaged snacks, chocolate and candies, packaged breads, sweetened breakfast cereals and pre-prepared "ready meals" like frozen dinners (Moubarac, 2017). For example, the energy share of fresh potatoes and other tubers in Canadians' food purchases from stores declined from 8.4% in 1938/1939 to 1.7% in 2001 (Moubarac, et al., 2014). By contrast, during the same time period, the energy share of chips and crackers increased from 0.0% to 2.9%. In 2015, ultra-processed products accounted for 45.7% of the total daily energy intake of Canadians (Polsky et al., 2020). Consumption was particularly high among children and adolescents, who consumed more than 50% of total energy from ultra-processed foods. In Canada, higher consumption of ultra-processed foods is associated with increased prevalence of obesity, diabetes and hypertension (Nardocci et al., 2019; Nardocci et al. 2021).

The transition from cooking meals from scratch and using fresh and minimally processed ingredients to buying ultra-processed products has a negative impact on people's health worldwide (Monteiro et al., 2018; Monteiro et al., 2019b). It also has a devasting impact on the planet, leading to increasing carbon emissions, water use and pollution (Seferidi et al., 2020). The current study suggests that the high consumption of ultra-processed products, as well as their overproduction, affect not only the health of Canadians, but also farmers' revenues.

Transforming the food system to further support farmers.

Considering the magnitude of the ultra-processing industry in the Canadian food system and its substantial impact on health, environment and the economy (Fardet & Rock, 2020), it is imperative that farmers, and particularly small producers, become more valued in Canada. Efforts to promote healthy eating patterns and

to reduce the consumption of ultra-processed products, in line with Canada's Food Guide recommendations, would help to revitalize the farming sector in Canada. This could include policies like front-of-package nutrition labelling, which help consumers make healthier choices, as well as restrictions on the marketing of unhealthy foods and beverages to children. In addition, alternative food systems could be introduced. For example, the enhancement of farmers' markets could provide greater value for farmers' products and thus generate a higher share of value added. Enhanced farmers' markets and other similar initiatives could create "alternative economic spaces" that promote healthy and eco-responsible food and social interactions and, importantly, enhance farmers' economic viability (Leyshon et al., 2003; Beckie et al., 2012).

Study limitations

This study has limitations, particularly related to Statistics Canada's classifications. The food products listed in Statistics Canada's Supply and Use Tables (SUTs) are grouped into conventional categories based on production and nutrient content, and do not allow for the disaggregation of foods within a given SUT. In this study, the category of "preserved and frozen foods," while composed mostly of ultra-processed products such as frozen dinners, also includes minimally processed foods (e.g., frozen fruits and vegetables) and processed foods (e.g., canned vegetables preserved with sodium), which are recommended as healthy options by Canada's Food Guide. Because Statistics Canada's SUTs do not allow for disaggregation, it was not possible to estimate the impact of consumer spending on healthy versus unhealthy options contained within this category. However, given the results of this analysis that consumer demand for ultra-processed products negatively impacts farmers' revenues, we can hypothesize that consumer spending on minimally processed and processed foods would provide farmers with higher revenues than preserved and frozen ultra-processed options.

The existing SUT's also limited the choice of food products for this study. For example, milk and milk products were grouped together as "fluid milk and processed milk products." It was not possible to perform a simulation to compare healthy versus unhealthy milk products because these products could not be disaggregated in the available SUT.

Furthermore, results of this study fit into a framework based on two assumptions used to construct the input-output model. The first assumption is that the demand for intermediate and primary inputs by an industry is proportional to its level of production, and the technical production coefficients (proportions) of a given industry are the same, regardless of the composition of production (technology specific to each industry). Second, the "market shares" of imports and different industries are constant and the same regardless of the origin of the demand (i.e., regardless of the demand category for final demand and regardless of the consuming industry for intermediate demand; these two assumptions are detailed in Appendix 1).

Conclusions

In 2017, Canadian farmers received a higher share of the food dollar and a higher share of revenues when consumers purchased healthy foods (defined in this study as fresh or minimally processed foods) than when they purchased unhealthy, ultra-processed foods. In contrast, the food processing industry received a higher share of the food dollar and higher revenues for ultra-processed foods. Taken together, this evidence points to the potential benefit of reorienting the Canadian food system toward one that fosters a fresh and minimally processed diet. Such a shift would benefit not only farmers, but also human and planetary health.

Developing policies to support, promote and protect the production and consumption of fresh and minimally processed foods is critical for supporting the agricultural sector and addressing the ongoing chronic disease crisis in Canada and globally. The 2019 Canada Food Guide's recommendation to limit the consumption of highly processed foods provides a strong basis for the development of such policies. Examples include front-of-package nutrition labelling and restrictions on the marketing of unhealthy foods and beverages to children and youth (Popkin et al., 2021). The implementation of such policies would benefit farmers by boosting their revenues, as suggested by this study's findings, while also enhancing the diet and health of Canadians. Future research should seek to better understand which strategies and policies would help to reorient the current food system toward one that is less processed.

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Appendix 1: The model

In this appendix, we provide a non-technical description of the model used in this study. But first, the following lines provide a very brief formal description.

The results presented in this study have been produced using a rectangular input-output model. The model was developed for the purposes of this project following the same principles as Statistique Québec's *Modèle intersectoriel du Québec* (Institut de la statistique du Québec, 2017). The rectangular format allows for products being supplied by more than one industry, and for industries to have more than a single output product. The rectangular format also mirrors the structure of Statistics Canada's Supply-and-use tables (SUT). All model parameters have been calibrated from the 2017 SUTs.

Our rectangular input-output model is based on the two following standard assumptions:

- **Assumption 1:** The demand for intermediate and primary inputs by an industry is proportional to its level of production and the technical production coefficients (proportions) in a given industry are the same, regardless of product-mix (industry technology assumption, as opposed to product technology assumption).
- **Assumption 2:** The "market shares" of imports and of each industry are constant and remain the same whatever the source of demand, that is to say whatever the category of demand in the case of final demand, and whatever the consuming industry in the case of intermediate demand.

Although it may be convenient to view the model's solution as an iterative process through successive "rounds" in the propagation of demand, these successive rounds must not be given a chronological interpretation. The model has no time dimension.

Finally, the input-output model is a model of the productive system, not of the whole economy, because factor incomes generated in production are not explicitly distributed to economic agents (households, businesses, government), and because these incomes do not give rise to additional demand by the agents (as they would in a computable general equilibrium model).

What the model does

The objective of the study was is to compare the impact of a consumer dollar on the Canadian economy for different food choices. The input-output model computes the way household consumption expenditures (and more generally final demand) cascade through the economy from the consumer (ultimate buyer) to first-round suppliers, then to suppliers of these suppliers (second-round suppliers), and further on to the third, fourth and subsequent rounds of suppliers. The input-output model is used to simulate the impact of a "demand shock", that is, any change in final demand. So the model answers questions like: What if consumers were to demand 1$ (or 1000$ or 4381.55 million $[2]) worth of fresh vegetables? For the purposes of this study, we simulated the impact of one consumer dollar of demand for each of the food products listed in Table 1.

How much of the consumer dollar gets to producers? (From acquisition prices to basic prices)

Before presenting the model itself, we describe a module that reformulates demand expressed in consumer dollars prior to feeding it into the model. Technically, that module performs the conversion from final demand in consumer dollars (at acquisition prices) to final demand at basic prices.

That conversion is necessary because when a consumer makes a purchase, the amount paid is not what the producer receives. First, there are taxes such as the GST and other taxes on products[3]. Then, there is the retailer's gross profit margin. And when the retailer passes the order on, the amount paid includes the wholesaler's margin and transport costs. So there are several deductions from the consumer dollar before the remainder is handed out to the producer.

It follows that in order to compare the impacts of consumer spending on different types of food, we must take into account that the deductions applied to the consumer dollar are different from one product to another. Technically speaking, this means converting consumer demand from "acquisition" prices (which include taxes on products and margins) to "basic" prices paid to producers. That conversion is performed for each different type of food before submitting the corresponding demand to the model for simulation.

The conversion is illustrated in Figure A1.1 below in the case of fresh vegetables. Taxes on fresh vegetables are tiny, but not zero, and for one consumer dollar, the actual demand for products is a shade less than one dollar (99.993¢). In the next step, the demand for products is split between fresh vegetables (60.567¢) and the various trade and transport margins (39.426¢). This is what we call the demand for products at basic prices that results from a one dollar consumer demand for fresh vegetables.

2 Actual figure for 2017.

3 Many food products however are exempt from GST.

Consumer dollar (final demand at acquisition prices)			Final demand for products at basic prices	
1.00000	Demand for products	0.99993	Fresh vegetables	0.60567
			Margins	0.39426
	Taxes on products	0.00007		

Figure A1.1 Deducting taxes and margins from one consumer dollar demand for fresh vegetables to obtain the amount actually spent on fresh vegetables

To summarize, the conversion from final demand at acquisition prices to final demand at basic prices involves two operations. The first is to subtract taxes on products. The second is to reallocate demand between (1) the product that is actually demanded, and (2) the various margins that are bundled up with it in the price paid by the consumer. The result of this conversion, final demand at basic prices, is what is then fed into the model.

Model step 1: First-round suppliers

The input-output model begins with the final demand for products at basic prices, and initially distributes that final demand among "first-round" suppliers. This is illustrated in Figure A1.2 for fresh vegetables.

The left part of Figure A1.2 just reproduces Figure A1.1. In the right part, final demand at basic prices for products, including margin products, is distributed between international imports and Canadian producers using proportions computed from the SUTs: from the original one consumer dollar of demand for fresh vegetables, 24.930¢ are spent on imports, and 75.063¢ go to Canadian producers. Those 75.063¢ are then assigned to different suppliers (again using proportions computed from the SUTs), amongst which "Agriculture" (short for Agricultural production and livestock) gets 35.761¢. The data in that final column is what is shown in Figure 3 and in Tables 4-6 of Appendix 3 for all the products considered in this study.

Consumer (final demand at acquisition prices)			Final demand for products at basic prices			First round suppliers		First-round Canadian suppliers (Appendix 3, Tables 4-6)	
1.00000	Demand for products	0.99993	**Fresh vegetables**	0.60567	Distribution of demand for products among suppliers	Imports	0.24930		
			Margins	0.39426		Canadian producers	0.75063	Agriculture	0.35761
								Food proces.	0.00415
								Distribution	0.33087
								Transport	0.02909
								Others	0.02891
								Sum	***0.75063***
	Taxes on products	0.00007							

Figure A1.2 Distribution of the consumer dollar among Canadian suppliers Fresh vegetables

Step 1 is not the end of the story

But the story doesn't end there. Indeed, if it did, there would be no need for a model. To illustrate why it would be misleading to consider only the impact on first-round suppliers, consider the impact of one consumer dollar's demand of fresh and frozen poultry. Figure A1.3 is similar to A1.2. What is remarkable though, is that in the first round, agriculture receives only 0.015¢ of the consumer dollar spent on poultry, while food processing gets 68.501¢.

Consumer (final demand at acquisition prices)			Final demand for products at basic prices			First round suppliers		First-round Canadian suppliers (Appendix 3, Tables 4-6)	
1.00000	Demand for products	0.99948	**Fresh & frozen poultry**	0.73411	Distribution of demand for products among suppliers	Imports	0.04762		
			Margins	0.26537		Canadian producers	0.95187	Agriculture	0.00015
								Food proces.	0.68501
								Distribution	0.22624
								Transport	0.01587
								Others	0.02459
								Sum	***0.95187***
	Taxes on products	0.00052							

Figure A1.3 Distribution of the consumer dollar among Canadian suppliers, Fresh and frozen poultry

However, to be able to produce output, the first-round suppliers need inputs, of which there are two kinds: (1) products used as inputs in the production of output; this is called intermediate demand; (2) so-called “primary factors” that are not products, such as labor or pre-existing capital (equipment, buildings…). The amount paid for these factors of production is called “Value added”. Also included among “primary factors” are taxes on products that apply to intermediate demand. So in step 2, the model distributes the intermediate demand for inputs generated by the first-round producers between suppliers (imports and Canadian producers), using proportions computed from the SUTs.

Figure A1.4 shows how this applies to the first-round production of the food-processing industries. Of the 68.501¢ received by the food-processing industries, 16.528¢ go to paying for primary inputs. The remaining 51.973¢ is used to buy imported products (3.068¢), and make purchases from Canadian producers (48.895¢).

Among the Canadian producers, agriculture gets 29.945¢. This is less than the 35.761¢ that goes to agriculture in the first round for fresh vegetables, but at least it’s in the same ballpark. Figure A1.4 clearly shows that a comparison of the impact of demand for fresh vegetable vs. fresh or frozen poultry would be greatly misleading if one were to consider only the numbers in Figures A1.2 and A1.3. Moreover, as the reader will have correctly guessed, a valid comparison should take into account not only rounds 1 and 2, but also all subsequent rounds in the propagation of demand. We will now show how this is done.

Input demand for the first-round production of the food-processing industries		Second-round suppliers of the food-processing industries		Second-round Canadian suppliers	
Products used as inputs	0.51973	Imports	0.03078		
		Canadian producers	0.48895	Agriculture	0.29945
				Food proces.	0.09556
				Distribution	0.01474
				Transport	0.01434
				Others	0.06485
Primary factors	0.16528				

Figure A1.4 Input demand from the first-round production of the food-processing industries, Fresh and frozen poultry

Subsequent steps in the model

Second-round producers need inputs, just like first-round producers. Part of the required intermediate inputs are imported, and part are supplied by Canadian producers, who in turn will need inputs. And so on and so forth... This “chain reaction” is illustrated in Figure A1.5.

It would seem the process goes on forever, and theoretically, it does. Note however that at each step, part of the demand flow leaks out, because (1) contrary to intermediate demand, value added (primary inputs) does not trigger more production, and (2) imports, which are produced abroad, do not call for supply from Canadian producers. So in each round, the amount of intermediate demand received from the previous round gets smaller and smaller, to the point of becoming insignificant. Technically, the whole process is said to converge to a finite solution.

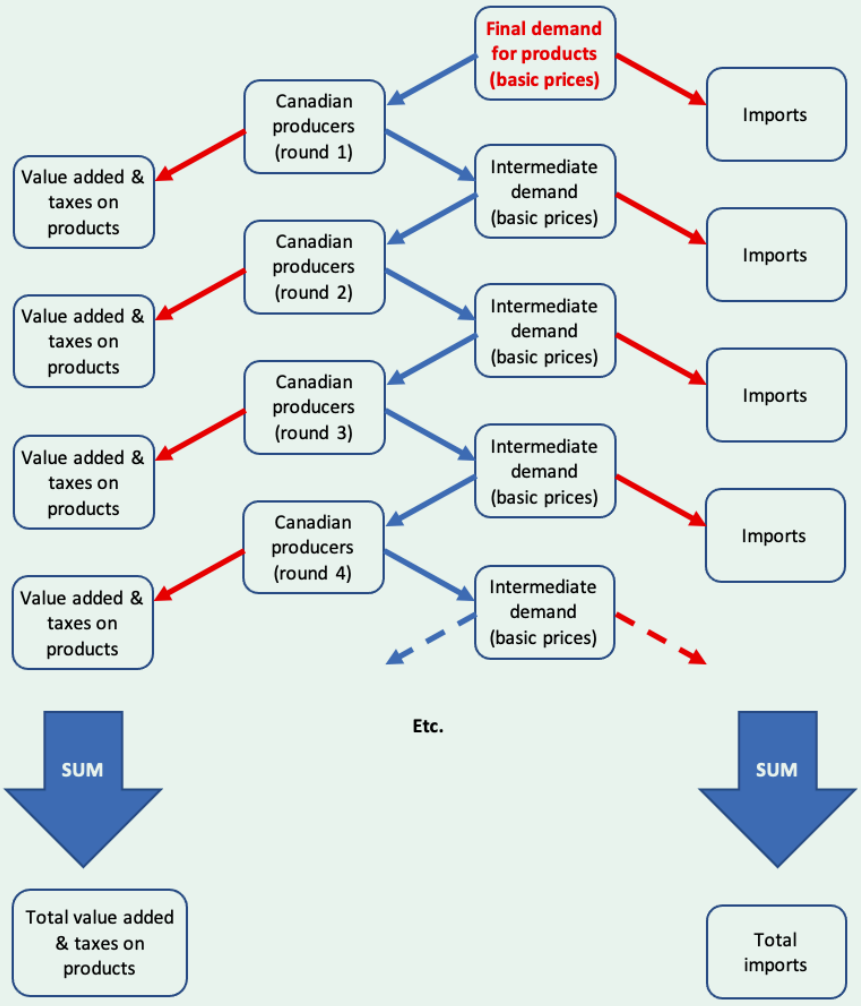

Figure A1.5 Successive rounds of intermediate demand and supply

What comes out of the model is the cumulative value added, the cumulative amount of taxes on products, and the cumulative imports generated directly and indirectly by the original consumer dollar.

The model also computes total output from the different Canadian supplying industries, as well as the total production of different products. But these are of little interest when one wants to compare the impact of the consumer dollar according to what it is used to buy. The reason is that it does not make sense to add up industry outputs to measure the impact. In effect, adding industry outputs amounts to summing the value of a loaf of bread produced by the bakery, the value of the flour produced at the mill, and the value of the grain produced on the farm; such summing up involves "double-counting", because the value of the grain is included the value of the flour, and the value of the flour is included the value of the bread.

Summing value added, on the contrary, involves no double-counting. The difference between the value of the loaf of bread and the cost of the flour and other ingredients (including energy, etc.) is the *additional* value (or value *added*) produced by the bakery; it consists of the value of the baker's labour, and of the services of his equipment (building, oven...). Likewise, the difference between the value of the flour and the value of the grain (and other inputs used in the milling process) is the value *added* by the milling process; it consists of the value of the miller's labour, and of the services of his equipment. In the end, if there were no imports or taxes on products, summing the values added at every stage of production, all the way down the line, would yield the value of the loaf of bread. In the real world, there are imports and taxes, and the sum of all imports and taxes on products down the line has to be summed up with total value added to obtain the *net* value of production, which in this simple example is the price of the loaf of bread.

Appendix 2: Mathematical presentation of the model

The results presented in this study have been produced using a rectangular input-output model. The model was developed for the purposes of this project following the same principles as Statistique Québec's *Modèle intersectoriel du Québec* (Institut de la statistique du Québec, 2017). The rectangular format allows for products being supplied by more than one industry, and for industries to have more than a single output product. The rectangular format also mirrors the structure of Statistics Canada's Supply-and-use tables (SUT). All model parameters have been calibrated from the 2017 SUTs. Details of the calibration procedure are available on demand.

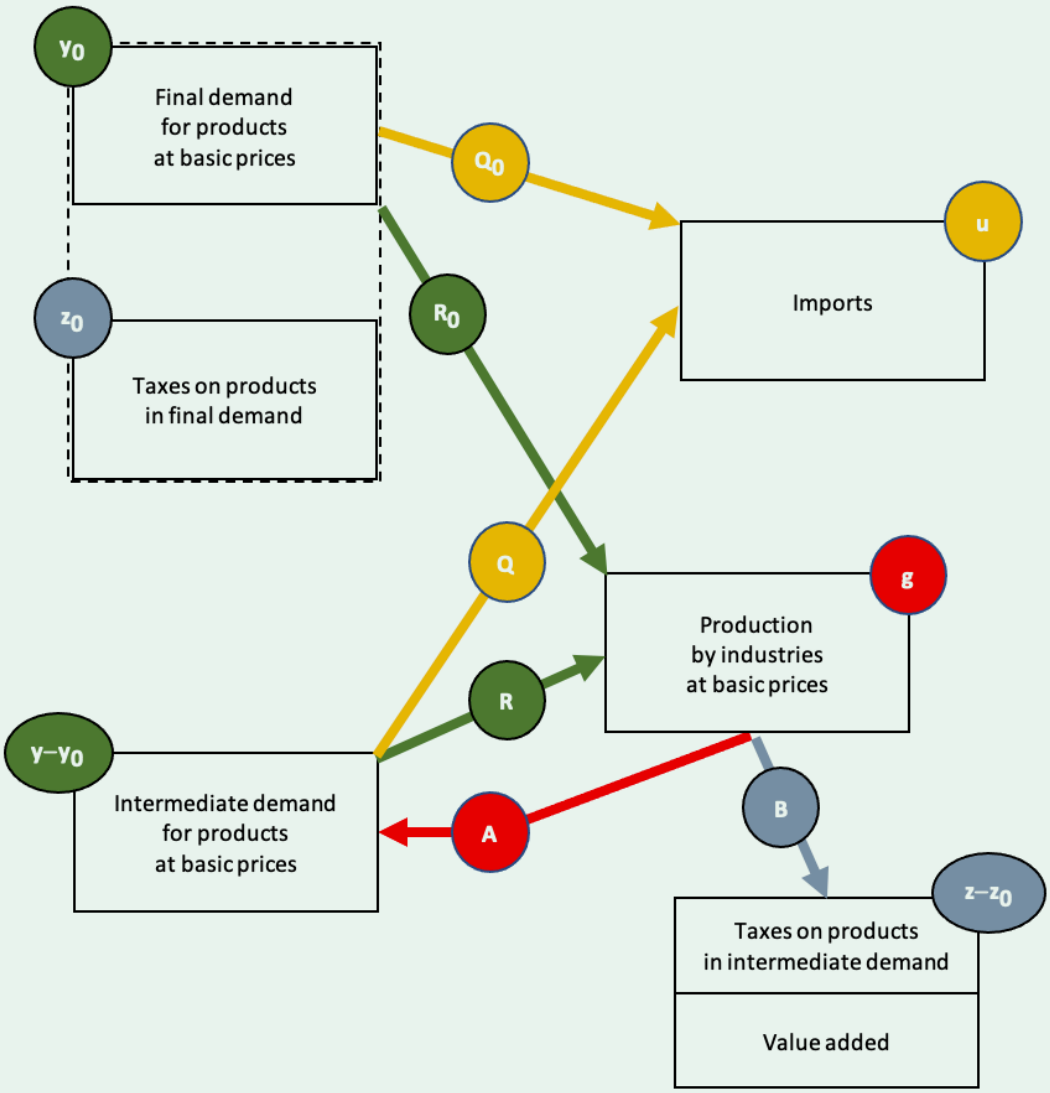

Figure A2.1 : Rectangular input-output model

Figure A2.1 gives a schematic representation of the model. Arrows represent relationships in the model. Mathematically, these relations are matrix products which transform one vector into another vector. Each arrow is labeled with the symbol of the corresponding matrix. The vectors are represented in Figure A2.1 by the boxes, which are labeled with the symbol of the corresponding vector.

In the model, there are *I* product ; *J* industries ; *H* categories of primary factors ; and a single category of "leaks" (demand flows that leak out of the domestic economy), international imports (*INTIM*).

In the following list of model matrices and vectors, the dimensions of each are given by the subscripts between parentheses.

A(*I*,*J*) : technical production coefficients; element *ai,j* in the matrix is the amount of product *i* purchased as an intermediate input by industry *j*, per dollar of production.

B(*H,J*) : technical primary factor input coefficients; element *bh,j* is the amount of primary factor *h* purchased as an input by industry *j*, per dollar of production.

R(*J*,*I*) : industry market share coefficients in the intermediate demand for products; element *rj,i* is the share of industry *j* in the supply of product *i* for intermediate demand.

R0(*J*,*I*) : industry market share coefficients in the final demand for products; in our input-output model, we have $\mathbf{R_0} = \mathbf{R}$.

Q(1,*I*) : market shares of other sources of intermediate demand supply of products; in our input-output model based on Statistic Canada's supply-and-use tables (SUTs), there is only one "other source", international imports; consequently, matrix **Q** has only one row, and *qINTIM,i* is the share of international imports (*INTIM*) in the supply of product *i* for intermediate demand.

Q0(1,*I*) : market shares of international imports ("other sources") in the final demand supply of products; in our model, we have $\mathbf{Q_0} = \mathbf{Q}$.

y(*I*) : vector of the total demand for products; *yi* is the total demand (final + intermediate) for product *i*.

y0(*I*) : vector of the final demand for products.

z(*H*) : vector of the total demand for primary factors; *zk* is the total demand for primary factor *k*.

z0(*H*) : vector of the final demand for primary factors; in our model based on Statistic Canada's supply-and-use tables (SUTs), all elements of that vector are zero, except for the amount of taxes on final demand products.

g(*J*) : vector of the production of industries; *gj* is the production of industry *j*.

u(1) : vector of the "leaks" in demand to other supply sources; in our model based on Statistic Canada's supply-and-use tables (SUTs), there is only one "other source", international imports; consequently, vector **u** has only one row, and *uINTIM* is the amount of international imports.

Our rectangular input-output model is based on the two following standard assumptions:

- **Assumption 1:** The demand for intermediate and primary inputs by an industry is proportional to its level of production and the technical production coefficients (proportions) in a given industry are the same, regardless of product-mix (industry technology assumption, as opposed to product technology assumption).
- **Assumption 2:** The "market shares" of imports and of each industry are constant and remain the same whatever the source of demand, that is to say whatever the category of demand in the case of final demand, and whatever the consuming industry in the case of intermediate demand.

Under these proportionality hypotheses, the following relationships are derived from the SUTs:

$$\mathbf{g} = \mathbf{R}_0\mathbf{y}_0 + \mathbf{R}(\mathbf{y} - \mathbf{y}_0) \qquad [A2.01]$$

$$\mathbf{u} = \mathbf{Q}_0\mathbf{y}_0 + \mathbf{Q}(\mathbf{y} - \mathbf{y}_0) \qquad [A2.02]$$

$$\mathbf{y} = \mathbf{y}_0 + \mathbf{A}\,\mathbf{g} \qquad [A2.03]$$

$$\mathbf{z} = \mathbf{z}_0 + \mathbf{B}\,\mathbf{g} \qquad [A2.04]$$

General model solution (matrix inversion)

To solve the model, substitute equation [A2.03] into [A2.01], and there obtains :

$$\mathbf{g} = \mathbf{R}_0\mathbf{y}_0 + \mathbf{R}(\mathbf{y}_0 + \mathbf{A}\,\mathbf{g} - \mathbf{y}_0) \qquad [A2.05]$$

or

$$\mathbf{g} = \mathbf{R}_0\mathbf{y}_0 + \mathbf{R}\,\mathbf{A}\,\mathbf{g} \qquad [A2.06]$$

$$(\mathbf{I} - \mathbf{R}\,\mathbf{A})\mathbf{g} = \mathbf{R}_0\mathbf{y}_0 \qquad [A2.07]$$

$$\mathbf{g} = (\mathbf{I} - \mathbf{R}\,\mathbf{A})^{-1}\mathbf{R}_0\mathbf{y}_0 \qquad [A2.08]$$

Once **g** has been determined, compute **z** using [A2.04], **y** using [A2.03], and **u** using [A2.02].

Since the model is linear, according to the proportionality hypotheses, its relations, and therefore its solution, are valid for any final demand $\mathbf{y}_0$. Of course, if $\mathbf{y}_0$ is defined as the observed final demand vector in the SUTs, the model solution must reproduce the observed industry levels of production and other variables in the SUTs. But the model is mainly used for simulation, to answer "what if" questions. In this study, we used the model to answer the question "what is the incremental impact on agriculture and other industries of a 1$ increase in consumer demand for such and such food product?"

Iterative solution of the model

The model can also be solved by an iterative method. That is made possible thanks to the proportionality hypotheses, according to which the model is linear, so that the relations between vectors remain valid to compute the impact in increments, following the propagation of the demand flow through the economy starting with the initial final demand.

The kernel of the iterative computation is illustrated in Figure A2.2 in the form of two fat arrows. The computation proceeds as follows:

- To satisfy final demand $\mathbf{y_0}$, the necessary production is $\mathbf{R}_0\mathbf{y}_0$; let us define $\mathbf{g}_0 = \mathbf{R}_0\mathbf{y}_0$, where the subscript zero refers to the initial round of demand propagation.
- To achieve levels of production $\mathbf{g_0}$, the industries demand intermediate inputs; that demand for intermediate inputs is given by $\mathbf{y}_1 = \mathbf{A}\,\mathbf{g}_0$ (round 1).
- In turn, this new slice of intermediate demand is supplied by a supplementary production equal to $\mathbf{g}_1 = \mathbf{R}\,\mathbf{y}_1 = \mathbf{R}\,\mathbf{A}\,\mathbf{g}_0$.
- To increase their production by $\mathbf{g_1}$, industries demand an extra slice of intermediate inputs, equal to $\mathbf{y}_2 = \mathbf{A}\,\mathbf{g}_1 = \mathbf{A}\,\mathbf{R}\,\mathbf{A}\,\mathbf{g}_0$.
- That leads to an increment in production of $\mathbf{g}_2 = \mathbf{R}\,\mathbf{y}_2 = \mathbf{R}\,\mathbf{A}\,\mathbf{R}\,\mathbf{A}\,\mathbf{g}_0 = (\mathbf{R}\,\mathbf{A})^2\,\mathbf{g}_0 \ldots$
- which generates a further increase in demand equal to $\mathbf{y}_3 = \mathbf{A}\,\mathbf{g}_2 = \mathbf{A}\,(\mathbf{R}\,\mathbf{A})^2\,\mathbf{g}_0$, and a further increase in production of $\mathbf{g}_3 = \mathbf{R}\,\mathbf{y}_3 = \mathbf{R}\,\mathbf{A}\,(\mathbf{R}\,\mathbf{A})^2\,\mathbf{g}_0 = (\mathbf{R}\,\mathbf{A})^3\,\mathbf{g}_0$.
- And so on, to infinity.

Following the iterative approach, the model solution is given by

$$\mathbf{g} = \mathbf{g}_0 + \mathbf{g}_1 + \mathbf{g}_2 + \mathbf{g}_3 + \cdots = \sum_{k=0}^{\infty} \mathbf{g}_k \qquad \text{[A2.09]}$$

that is

$$\mathbf{g} = \mathbf{g}_0 + (\mathbf{R}\,\mathbf{A})\,\mathbf{g}_0 + (\mathbf{R}\,\mathbf{A})^2\,\mathbf{g}_0 + (\mathbf{R}\,\mathbf{A})^3\,\mathbf{g}_0 + \cdots = \left(\sum_{k=0}^{\infty} (\mathbf{R}\,\mathbf{A})^k\right)\mathbf{g}_0 = \left(\sum_{k=0}^{\infty} (\mathbf{R}\,\mathbf{A})^k\right)\mathbf{R}_0\mathbf{y}_0 \qquad \text{[A2.10]}$$

That sum of an infinite number of terms converges to a matrix with finite values. Indeed, it can be demonstrated that

$$\left(\sum_{k=0}^{\infty} (\mathbf{R}\,\mathbf{A})^k\right) = (\mathbf{I} - \mathbf{R}\,\mathbf{A})^{-1} \qquad \text{[A2.11]}$$

The iterative solution is therefore identical to the general solution obtained by matrix inversion.

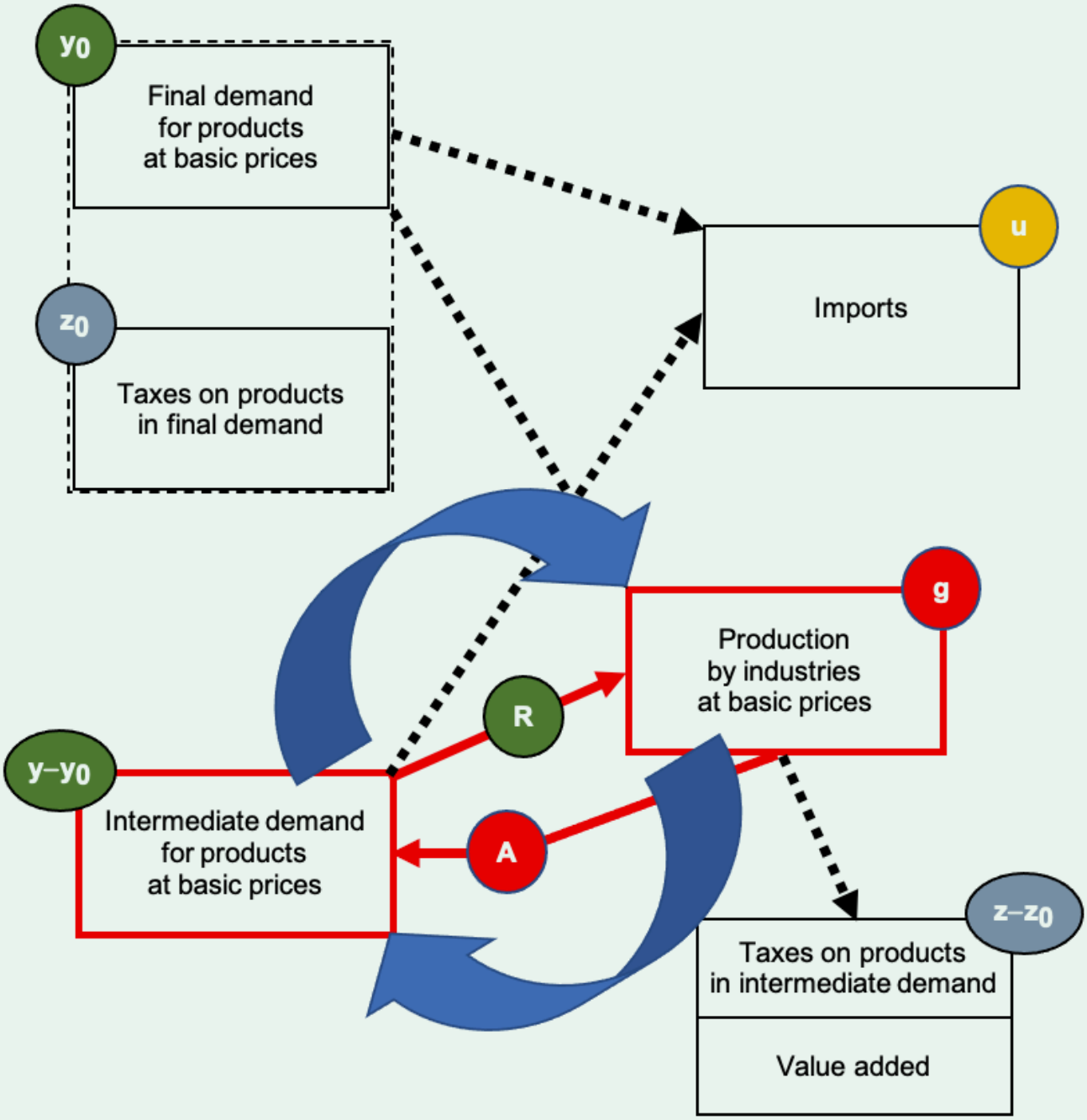

Figure A2.2 : Rectangular input-output model - Iterative solution

National accounting identity

It is of interest for the purposes of this study to take note of the fact that, by construction, the model solution verifies the national accounting identity (for a proof applied to this particular model, see Lemelin, 2021). In our model, this accounting identity may be written in the form

$$\left(\sum_i y0_i + \sum_h z0_h\right) = \sum_h z_h + u_{INTIM} \qquad \text{[A2.12]}$$

where $y0_i$ is the i^{th} element of vector $\mathbf{y_0}$, and $z0_h$ is the h^{th} element of vector $\mathbf{z_0}$.

On the left-hand side, $\sum_i y0_i$ is the amount of final demand for products at basic prices, and $\sum_h z0_h$ is the amount of taxes on products paid on final demand (recall that in our model, all elements of $\mathbf{z_0}$ are zero, except for the amount of taxes on final demand products). It follows that $\left(\sum_i y0_i + \sum_h z0_h\right)$ is the amount of final demand at acquisition prices. In our simulations, that amount was 1$.

On the right-hand side of identity [A2.12] we can separate the sum $\sum_h z_h$ into two components:

$$\sum_h z_h = \{\text{value added}\} + \{\text{taxes on products}\}$$

Finally, u_{INTIM} is the amount of international imports. We can now interpret the meaning of [A2.12]:

$$\begin{aligned}\{\text{amount of final demand at acquisition prices}\} = {} & \{\text{value added}\} \\ & + \{\text{taxes on products}\} \\ & + \{\text{amount of international imports}\}\end{aligned}$$

This decomposition is what is presented in Figures 3 and 4 and in Appendix 4. It takes into account the entire impact of the simulated final demand on producers' revenue (value added). By contrast, the decomposition presented in Figures 1 and 2 and in Appendix 3 only take into account first-round suppliers. Mathematically, the tables in Appendix 3 are computed as $\mathbf{Ry_0}$ and $\mathbf{Qy_0}$

Appendix 3: Detailed data of Figure 1 and Figure 3

3.1 Distribution of the impact of one dollar spent by consumers in 2017 between taxes, imports and value added generated by farmers and other sectors in the Canadian economy

Food category	Farmer's revenues	Farmers-other added value	Food processing	Distribution	Transport and storage	Other sectors	Imports	Taxes	Total ($)
Fresh potatoes	0.21461444	0.0419383	0.0036660	0.2579055	0.0321470	0.277452	0.1656377	0.0066389	1
Fresh vegetables	0.12844991	0.0591835	0.0027734	0.2147096	0.0246751	0.2249315	0.3389778	0.0062991	1
Fruits and nuts	0.04943562	0.0096966	0.0023121	0.1723048	0.0217692	0.1387349	0.6011894	0.0045574	1
Fruit and vegetables juices	0.01392190	0.0040873	0.0992007	0.2756570	0.0408214	0.2412088	0.3094968	0.0156060	1
Preserved and frozen foods	0.02129416	0.0061695	0.1360619	0.2176654	0.0326787	0.2227502	0.3526049	0.0107752	1
Cookies, crackers and sweet goods	0.01700587	0.0037336	0.2236805	0.1721829	0.0319877	0.2336439	0.2978085	0.0199569	1
Snack products	0.02411835	0.0058037	0.1776815	0.1611270	0.0268319	0.1889085	0.3166182	0.0989109	1
Fresh beef and veal	0.09270671	0.0271440	0.1670243	0.1809382	0.0395592	0.2778319	0.2086269	0.0061687	1
Fresh pork	0.09698196	0.0283469	0.1742723	0.1928421	0.0354337	0.2881761	0.1791319	0.0048150	1
Fresh poultry	0.10862594	0.0317780	0.1952213	0.1651201	0.0309727	0.2874788	0.1765348	0.0042682	1
Processed meats	0.08201242	0.0240260	0.1476741	0.1853189	0.0263642	0.2542354	0.2749531	0.0054159	1

Appendix 4:
Detailed data for Table 3 and Figure 4

4.1. Revenues and other detailed components of the value added generated in sectors of the food system in response to one dollar of final demand for fresh fruits and nuts in 2017.

Fresh fruits and nuts

	Agricultural production and livestock	Food processing	Distribution	Transport and storage	Other industrial sectors	Total of each component of the value added
Subsidies on production	-0.0034992	-0.0000031	-0.0000230	-0,0000310	-0.0005189	-0.0040753
Production taxes	0.004705	0.0000408	0.0044422	0,0005055	0.007288	0.0169815
Salaries and treatments	0.0080783	0.0009825	0.1047700	0,0112709	0.0644332	0.1895349
Social contributions payable by employers	0.0004126	0.0003091	0.0136857	0,0014593	0.0087813	0.0246481
Gross mixed income	0.0217942	0.0000069	0.0113711	0,0018504	0.0117997	0.0468224
Operating surplus	0.0276414	0.0009758	0.0380588	0,0067141	0.0469515	0.1203416
Total revenues (gross mixed income + operating surplus) (% of total revenues)	0.0494356 (29.6%)	0.0009828 (0.6%)	0.0494299 (29.6%)	0,0085644 (5,1%)	0.0587513 (35.1%)	0.1671640 (100%)
Total gross value added at basic prices (GDP)	0.0591323	0.0023121	0.1723048	0,0217692	0.1387349	0.3942532

4.2 Revenues and other detailed components of the value added generated in sectors of the food system in response to one dollar of final demand for fresh vegetables (except potatoes) in 2017.

Fresh vegetables (except potatoes)

	Agricultural production and livestock	Food processing	Distribution	Transport and storage	Other industrial sectors	Total of each component of the value added
Subsidies on production	-0.0079697	-0.0000037	-0.0000318	-0.0000324	-0.0007292	-0.0087669
Production taxes	0.0113485	0.0000514	0.0055821	0.0005856	0.0112917	0.0288592
Salaries and treatments	0.0532011	0.0011706	0.1313893	0.0125614	0.1022201	0.3005425
Social contributions payable by employers	0.0026037	0.0003703	0.0171785	0.0016803	0.0143528	0.0361856
Gross mixed income	0.0574715	0.0000080	0.0143926	0.0019357	0.0182010	0.0920087
Operating surplus	0.0709784	0.0011769	0.0461989	0.0079446	0.0795952	0.2058940
Total revenues (gross mixed income + operating surplus)	0.1284499 (43.1%)	0.0011849 (0.4%)	0.0605915 (20.3%)	0.0098802 (3.3%)	0.0977962 (32.8%)	0.2979027 (100%)
Total gross value added at basic prices (GDP)	0.1876335	0.0027734	0.2147096	0.0246751	0.2249316	0.6547231

4.3 Revenues and other detailed components of the value added generated in sectors of the food system in response to one dollar of final demand for fresh potatoes in 2017.

Fresh potatoes

	Agricultural production and livestock	Food processing	Distribution	Transport and storage	Other industrial sectors	Total of each component of the value added
Subsidies on production	-0.0151855	-0.0000050	-0.0000397	-0.0000404	-0.0008843	-0.0161549
Production taxes	0.0204598	0.0000657	0.0066249	0.0007707	0.0133278	0.041249
Salaries and treatments	0.0348853	0.0015538	0.1558274	0.0161664	0.1260122	0.3344451
Social contributions payable by employers	0.0017787	0.0004897	0.0203641	0.0022065	0.0175828	0.0424219
Gross mixed income	0.0946113	0.0000108	0.0166195	0.0024137	0.0220187	0.1356740
Operating surplus	0.1200031	0.0015509	0.0585093	0.0106300	0.0993948	0.2900882
Total revenues (gross mixed income + operating surplus)	0.2146144 (50.4%)	0.0015618 (0.4%)	0.0751287 (17.7%)	0.0130437 (3.1%)	0.1214135 (28.5%)	0.4257622 (100%)
Total gross value added at basic prices (GDP)	0.2565527	0.0036660	0.2579055	0.0321470	0.2774521	0.8277234

4.4 Revenues and other detailed components of the value added generated in sectors of the food system in response to one dollar of final demand for fresh and frozen beef and veal in 2017.

Fresh and frozen beef and veal

	Agricultural production and livestock	Food processing	Distribution	Transport and storage	Other industrial sectors	Total of each component of the value added
Subsidies on production	-0.0076225	-0.0000447	-0.0000305	-0.0000516	-0.0008295	-0.0085787
Production taxes	0.0066098	0.0019026	0.0048212	0.0010144	0.0124551	0.026803
Salaries and treatments	0.0266916	0.0738543	0.1129969	0.0204384	0.1286007	0.3625820
Social contributions payable by employers	0.0014651	0.0240712	0.0147170	0.0027157	0.0183053	0.0612743
Gross mixed income	0.0410256	0.0003925	0.0129250	0.0030968	0.0219931	0.0794330
Operating surplus	0.0516811	0.0668483	0.0355086	0.0123455	0.0973072	0.2636907
Total revenues (gross mixed income + operating surplus)	0.0927067 (27.0%)	0.0672408 (19.6%)	0.0484336 (14.1%)	0.0154423 (4.5%)	0.1193002 (34.8%)	0.3431237 (100%)
Total gross value added at basic prices (GDP)	0.1198508	0.1670243	0.1809382	0.0395592	0.2778319	0.7852043

4.5 Revenues and other detailed components of the value added generated in sectors of the food system in response to one dollar of final demand for fresh and frozen poultry of all types in 2017.

Fresh and frozen poultry of all types

	Agricultural production and livestock	Food processing	Distribution	Transport and storage	Other industrial sectors	Total of each component of the value added
Subsidies on production	-0.0089288	-0.0000521	-0.0000294	-0.0000353	-0.0008248	-0.0098703
Production taxes	0.0077512	0.0022207	0.0043396	0.0008609	0.0123705	0.0275429
Salaries and treatments	0.0312410	0.0863333	0.1016073	0.0158434	0.1330523	0.3680772
Social contributions payable by employers	0.0017146	0.0281388	0.0132093	0.0021872	0.0190709	0.0643209
Gross mixed income	0.0480700	0.0004588	0.0113004	0.0021280	0.0224608	0.0844179
Operating surplus	0.0605559	0.0781218	0.0346929	0.0099884	0.1013492	0.2847083
Total revenues (gross mixed income + operating surplus)	0.1086259 (29.4%)	0.0785806 (21.3%)	0.0459933 (12.5%)	0.0121165 (3.3%)	0.1238099 (33.5%)	0.3691262 (100%)
Total gross value added at basic prices (GDP)	0.1404040	0.1952213	0.1651201	0.0309727	0.2874788	0.8191970

4.6 Revenues and other detailed components of the value added generated in sectors of the food system in response to one dollar of final demand for fresh and frozen pork in 2017.

Fresh and frozen pork

	Agricultural production and livestock	Food processing	Distribution	Transport and storage	Other industrial sectors	Total of each component of the value added
Subsidies on production	-0.0079672	-0.0000474	-0.0000317	-0.0000434	-0.0008677	-0.0089574
Production taxes	0.0069269	0.0019864	0.0050148	0.009445	0.0127335	0.0276061
Salaries and treatments	0.0278581	0.0770583	0.1176861	0.0182338	0.1336794	0.3745158
Social contributions payable by employers	0.0015290	0.0251106	0.0153112	0.0024659	0.0190394	0.0634560
Gross mixed income	0.0429169	0.0004102	0.0128828	0.0026124	0.0227271	0.0815494
Operating surplus	0.0540650	0.0697542	0.0419789	0.0112207	0.1008644	0.2778832
Total revenues (gross mixed income + operating surplus)	0.0969820 (27.0%)	0.0701644 (19.5%)	0.0548616 (15.3%)	0.0138330 (3,8%)	0.1235915 (34.3%)	0.3594325 (100%)
Total gross value added at basic prices (GDP)	0.1253288	0.1742723	0.1928421	0.0354337	0.2881761	0.8160531

4.7 Revenues and other detailed components of the value added generated in sectors of the food system in response to one dollar of final demand for fresh, frozen and canned fruit and vegetable juices in 2017.

Fresh, frozen and canned fruit and vegetable juices

	Agricultural production and livestock	Food processing	Distribution	Transport and storage	Other industrial sectors	Total of each component of the value added
Subsidies on production	-0.0009603	-0.0004732	-0.0000322	-0.0000545	-0.0009247	-0.0024449
Production taxes	0.0012358	0.0015170	0.0065334	0.0010762	0.0113519	0.0217143
Salaries and treatments	0.0036244	0.0437191	0.1548336	0.0215139	0.1151404	0.3388314
Social contributions payable by employers	0.0001873	0.0143998	0.0201393	0.0028038	0.0164485	0.0539787
Gross mixed income	0.0061758	0.0001719	0.0140476	0.0032722	0.0178947	0.0415621
Operating surplus	0.0077461	0.0398662	0.0801353	0.0122099	0.0812981	0.2212556
Total revenues (gross mixed income + operating surplus)	0.0139219 (5.3%)	0.0400381 (15.2%)	0.0941829 (35.8%)	0.0154821 (5.9%)	0.0991928 (37.7%)	0.2628177 (100%)
Total gross value added at basic prices (GDP)	0.0180092	0.0992008	0.2756570	0.0408214	0.2412088	0.6748972

4.8 Revenues and other detailed components of the value added generated in sectors of the food system in response to one dollar of final demand for preserved fruits and vegetables and frozen foods in 2017.

Preserved fruits and vegetables and frozen foods

	Agricultural production and livestock	Food processing	Distribution	Transport and storage	Other industrial sectors	Total of each component of the value added
Subsidies on production	-0.0014818	-0.0006730	-0.0000278	-0.0000403	-0.0007916	-0.0030144
Production taxes	0.0018884	0.0019604	0.0054032	0.0009272	0.0106171	0.0207963
Salaries and treatments	0.0054804	0.0573118	0.1276208	0.0172181	0.1055257	0.3131568
Social contributions payable by employers	0.0002824	0.0183051	0.0166297	0.0022891	0.0153551	0.0528614
Gross mixed income	0.0094448	0.0003232	0.0128276	0.0024309	0.0161898	0.0412163
Operating surplus	0.0118493	0.0588343	0.0552119	0.0098537	0.0758542	0.2116035
Total revenues (gross mixed income + operating surplus)	0.0212942 (8.4%)	0.0591575 (23.4%)	0.0680395 (26.9%)	0.0122846 (4.9%)	0.0920440 (36.4%)	0.2528198 (100%)
Total gross value added at basic prices (GDP)	0.0274637	0.1360619	0.2176654	0.0326787	0.2227502	0.6366199

4.9 Revenues and other detailed components of the value added generated in sectors of the food system in response to one dollar of final demand for baked cookies, crackers and sweet goods in 2017.

Baked cookies, crackers and sweet goods

	Agricultural production and livestock	Food processing	Distribution	Transport and storage	Other industrial sectors	Total of each component of the value added
Subsidies on production	-0.0012166	-0.0000657	-0.0000234	-0.0000346	-0.0007510	-0.0020913
Production taxes	0.0015544	0.0025200	0.0042811	0.008137	0.0103083	0.0194775
Salaries and treatments	0.0032268	0.1077874	0.1009578	0.0156840	0.1103984	0.3380544
Social contributions payable by employers	0.0001690	0.0307447	0.0131382	0.0022545	0.0163525	0.0626589
Gross mixed income	0.0075112	0.0010997	0.0101555	0.0020770	0.0151648	0.0360082
Operating surplus	0.0094946	0.0815945	0.0436737	0.0111931	0.0821709	0.2281269
Total revenues (gross mixed income + operating surplus)	0.0170059 (6.4%)	0.0826943 (31.3%)	0.0538291 (20.4%)	0.0132700 (5.0%)	0.0973357 (36.9%)	0.2641350 (100%)
Total gross value added at basic prices (GDP)	0.0207395	0.2236806	0.1721829	0.0319877	0.2336439	0.6822345

4.10 Revenues and other detailed components of the value added generated in sectors of the food system in response to one dollar of final demand for snack food products in 2017.

Snack food products

	Agricultural production and livestock	Food processing	Distribution	Transport and storage	Other industrial sectors	Total of each component of the value added
Subsidies on production	-0.0017273	-0.0001858	-0.0000223	-0.0000306	-0.0006613	-0.0026273
Production taxes	0.0021651	0.0016903	0.0040377	0.0007498	0.0087749	0.0174178
Salaries and treatments	0.0050996	0.0767164	0.0952230	0.0137619	0.0897869	0.2805877
Social contributions payable by employers	0.0002664	0.0182418	0.0124003	0.0018964	0.0130308	0.0458357
Gross mixed income	0.0106731	0.0010845	0.0097502	0.0018469	0.0133197	0.0366745
Operating surplus	0.0134452	0.0801343	0.0397381	0.0086076	0.0646574	0.2065826
Total revenues (gross mixed income + operating surplus)	0.0241184 (9.9%)	0.0812188 (33.4%)	0.0494883 (20.3%)	0.0104545 (4.3%)	0.0779772 (32.1%)	0.2432571 (100%)
Total gross value added at basic prices (GDP)	0.0299220	0.1776815	0.1611270	0.0268319	0.1889085	0.5844710

4.11 Revenues and other detailed components of the value added generated in sectors of the food system in response to one dollar of final demand for processed meat products, other miscellaneous meats and animal by-products in 2017.

Processed meat products, other miscellaneous meats and animal by-products

	Agricultural production and livestock	Food processing	Distribution	Transport and storage	Other industrial sectors	Total of each component of the value added
Subsidies on production	-0.0066488	-0.0000752	-0.0000296	-0.0000291	-0.0007831	-0.0075658
Production taxes	0.0058345	0.0016893	0.0048451	0.0007266	0.0114658	0.0245614
Salaries and treatments	0.0235293	0.0654473	0.1137691	0.0133617	0.1182369	0.3343442
Social contributions payable by employers	0.0013110	0.0212209	0.0148128	0.0018681	0.0167827	0.0559955
Gross mixed income	0.0363579	0.0003471	0.0126015	0.0017526	0.0203545	0.0714136
Operating surplus	0.0456545	0.0590447	0.0393201	0.0086842	0.0881786	0.2408821
Total revenues (gross mixed income + operating surplus)	0.0820124 (26.3%)	0.0593918 (19.0%)	0.0519216 (16,6%)	0.0104369 (3.3%)	0.1085331 (34.8%)	0.3122957 (100%)
Total gross value added at basic prices (GDP)	0.1060384	0.1476741	0.1853189	0.0263642	0.2542354	0.7196310