Returns to Potatoes USA Marketing Programs

Timothy J. Richards *Arizona State University*

Over the 2016 - 2020 study period, potato shipments were initially stable, and then declined substantially. Grower prices, however, remained high. Four years of remarkable stability from 2015 - 2018 were interrupted by sharp declines in demand in 2019, and then the COVID-19 pandemic year of 2020. While 2020 likely represented an outlier in terms of market demand for potatoes, in general, marketing activities funded by Potatoes USA may have prevented a steeper decline. In this report, we summarize our findings from an econometric analysis of Potatoes USA marketing activities and answer the question: Where would the industry have been in the absence of Potatoes USA?

Executive Summary

- The objective of this study is to determine the return on investment for marketing activities funded by Potatoes USA stakeholders. We examine three markets in which U.S.-grown potatoes are typically sold: The retail market, consisting of sales through supermarkets, club stores and other outlets; the foodservice market, which consists of restaurants, cafeterias, and institutional food delivery services such as schools and hospitals; and export markets throughout the world. Potatoes are sold into all markets in many different forms – fresh, frozen, chips, dehydrated, and seed, for example – and in many different package-variants. In this study, we focus on how Potatoes USA activities influence the demand, and the profitability, of selling any type of potato, into either the retail, foodservice, or export markets.

- We calculate the returns to Potatoes USA marketing activities using models of potato supply, demand, and market equilibrium. That is, we assume marketing activities affect the weekly (or monthly, depending on the market) demand-flow for potatoes. Given the existing supply of potatoes, the market price will adjust to clear the market, or equate supply and demand. The resulting price impact is used to calculate the marginal impact on grower profit, and return to the amount of funds invested. We develop three equilibrium models that follow this same logic, one for the retail market, another for foodservice sales, and a third for the export market.

- All models are estimated with data made available from Potatoes USA, IRI, USDA, Department of Commerce, and from internal organization records. Our retail data are provided by IRI through their contract with Potatoes USA, while the foodservice movement data are imputed from USDA-NASS, and IRI retail movements. Our export data are from United States Department of Commerce, Foreign Trade Division (Harmonized Coding System, Schedule B) sources. Marketing investment data are derived from Potatoes USA financial records, and are categorized into consumer, retail, nutrition, digital, research, and foodservice investments. We assume investments in each category influence retail and foodservice potato demand, but we estimate each model with these categorizations collapsed into one that captured all retail, foodservice, and consumer-oriented investments. In the export market, investment data are derived from Potatoes USA financial records. Export promotion expenditures from individual activities are aggregated into one overall activity that represents all export demand enhancing activities.

- For each model (retail, foodservice, and export), we estimate short- and long-run elasticity values for five different demand drivers: (1) price, (2) price-promotion (retail model), (3) demand-dynamics, (4) macroeconomic factors, and (5) marketing investments. Importantly, the statistical method used provides elasticity estimates for each variable, *holding each of the others constant*. Elasticity is defined as the ratio of the percentage change in demand to the percentage change in the variable of interest. Elasticities are important as they are unit-free measures of the responsiveness of demand to each variable.

- The short-run retail price elasticity of demand is -0.418 on average over all potato categories (fresh, frozen, potato chips, dehydrated potato products, canned, deli, and refrigerated), and regions, while the long-run retail price elasticity is -0.484. In other words, if the retail price rises by 1 percent, demand is expected to fall by 0.418 percent in the short run, and 0.484 percent in the long run. Our estimate is slightly smaller than recent estimates from other studies because the retail data is aggregated over stores, brands, packages, and other ways in which retail potatoes are differentiated in the retail market. The short-run elasticity of consumer-focused marketing investments is 0.037 for fresh, 0.025 for frozen, 0.039 for chips, 0.017 for canned, 0.041 for dehydrated, 0.045 for deli potatoes, and 0.039 for refrigerated products. The long-run marketing elasticities in the retail market are 0.041 for fresh, 0.027 for frozen, 0.043 for chips, 0.019 for canned, 0.045 for dehydrated, 0.050 for deli potatoes, and 0.043 for refrigerated products.. Each estimate is highly statistically significant.

- We measure return on investment using two, equivalent metrics: (1) the benefit:cost ratio (BCR), and (2) return on investment (ROI). BCR is calculated as the present value of grower profit divided by the amount of investment, while ROI is the same calculation expressed as a percentage of the initial investment. In this summary, we report both BCR and ROI values, but they are equivalent measures of investment return.

- We calculate BCR values for marketing investments in the retail market for each product-type. The estimated short-run BCR for fresh potatoes is 2.312 (2.312 dollars in profit for the next 1.00 dollar invested) and 2.468 in the long run. These BCR values imply ROIs of 131.2% in the short run and 146.8% in the long run. The BCR for marketing investments in the frozen market is 1.535 in the short run, and 1.639 in the long run, which imply ROIs of 53.5% in the short run and 63.9% in the long run. For chips, the short run BCR is 2.411 (ROI = 141.1%), while it is 2.573 in the long run (ROI = 157.3%). Marketing investments in the canned potato market yield a BCR of 1.062 in the short run (ROI = 6.2%), and 1.133 in the long run (ROI = 13.3%). The returns for dehydrated potatoes are 2.542 in the short run (ROI = 154.2%), and 2.713 in the long run (ROI = 171.3%), while they are 2.790 in the short run (ROI = 179.0%) and 2.978 in the long run (ROI = 197.8%) for deli potatoes in the retail market. Finally, the returns to refrigerated potato products are 2.427 in the short run (ROI = 142.7%) and 2.591 in the long run (ROI = 159.1%). In general, therefore, marketing investments in the retail market provide returns that are likely far above growers' return on competing investments.

- There are no data sources that accurately measure the demand for foodservice potatoes directly. Therefore, we imputed the volume of foodservice demand by subtracting retail and export market flows from USDA Market News Service monthly shipment volumes. The result is likely to be highly correlated with actual foodservice-market demand as annual potato production is used only for retail, export, and foodservice market purposes. Foodservice demand was estimated as a function of lagged demand, prices, marketing investments, macroeconomic factors, and fixed geographic and yearly effects. As in the retail market, we differentiated between different types of potato in the foodservice market: Fresh, chips, frozen, refrigerated, and dehydrated potatoes. The average price elasticity of demand in the foodservice market was -0.687 in the short run and -0.742 the long run, on average over all potato types and regional markets. All estimated parameters were highly statistically significant. The elasticity with respect to consumer marketing is 0.047 in the short run and 0.051 in the long run for fresh potatoes, 0.038 in the short run and 0.041 in the long run for chips, 0.041 in the short run and 0.044 in the long run for frozen potatoes, 0.042 in the short run and 0.046 in the long run for refrigerated potatoes, and 0.040 in the short run and 0.043 in the long run for dehydrated products. Somewhat surprisingly, our estimates show little difference between the short- and long-run demand in the foodservice market, reflecting perhaps volatile demand conditions facing restaurant and other institutional buyers.

- We also calculated the return on investment to Potatoes USA marketing activities in the foodservice market. As in the retail market, our measure of marketing activity combines efforts to reach consumers through nutritional, retail, foodservice and other types of messages. Consumer-facing activities in the foodservice market has a BCR of 3.597 in the short run for fresh potatoes (ROI = 259.7%), and a BCR of 3.739 in the long run (ROI = 273.9%). The estimated BCR for potato chips is 2.883 in the short run (ROI = 188.3%) and 2.997 in the long run (ROI = 199.7%). Returns to frozen potato marketing in the foodservice market are 3.117 in the short run (ROI = 211.7%) and 3.240 (ROI = 224.0%) in the long run. For refrigerated potatoes, marketing in the foodservice market returns 3.244 dollars of incremental profit for the next dollar invested in the short run (ROI = 224.4%) and 3.373 (ROI = 237.3%) in the long run. Returns to marketing in the dehydrated market are 3.090 in the short run (ROI = 209.0%) and 3.212 in the long run (ROI = 221.2%). In both the short- and long-runs, therefore, all marketing activities in the foodservice market appear to be highly profitable, and yield returns well in excess of growers' opportunity costs of capital (approximately 5.0%).

- We also estimated returns to export marketing (combining Market Access Program (MAP) and Potatoes USA funding) in 8 different export markets, for four different types of potato products (fresh, frozen, dehydrated, and seed). Our demand models take into account regional and temporal variation in economic growth (Gross Domestic Product (GDP)), exchange rates, inflation, and unobserved factors in each country / product pair. Our estimated export-market BCRs are also consistently larger than 1.0, indicating that the benefits of export promotion are larger than the costs. Specifically, the BCRs for dehydrated, fresh, frozen, and seed potato export promotion are 1.550, 2.009, 2.009, and 1.283 in the short-run, respectively (ROI = 55.0%, 100.9%, 100.9%, and 128.3%). The long-run estimates reflect the fact that the effect of marketing investments is likely to persist over time, and are larger than the our short run estimates, ranging from 1.343 (ROI = 34.3%) for seed potatoes, to 2.323 (ROI = 132.3%) for dehydrated potato products. The overall BCR for all four programs is 1.783 in the short-run, and 1.836 in the long-run. Based on these average BCRs, it appears that dehydrated potato export promotion offered the highest return on investment followed by fresh, frozen, then seed-potato export promotion.

Introduction

According to USDA-NASS, total potato shipments in the US were some 450.0 million cwt in 2016, and had fallen to 420 million cwt by 2020 (see figure 1). However, grower prices averaged $9.08 per cwt in 2016, and rose to $9.30 per cwt in 2020, only to rise further to $9.92 per cwt by 2021 (USDA-NASS). From an economic perspective, lower demand for any consumer product is to be expected when prices rise. While some of the rise in grower prices over our sample period was likely due to the unprecedented increase in retail demand due to the COVID-19 pandemic in 2020, Potatoes USA was also actively marketing potatoes over this period. In this report, we seek to disentangle the effect of the COVID-19 pandemic and the associated dislocation between the foodservice and retail markets, longer-term trends in demand, changes in production, and Potatoes USA marketing activities in order to estimate the "all-else-constant" effect of Potatoes USA market investments on potato demand.

Econometric analysis is required to determine where potato consumption would be in the absence of any Potatoes USA marketing activities. Because the food market is a crowded place, and growing demand is difficult, it is necessary to control for all possible factors that may have influenced potato consumption and prices in order to disentangle the unique effect of Potatoes USA's investments in growing consumer and export demand. The difference between what we observe in sales reports and "what might have been" constitutes a return on investment. In this study, we quantify that return and determine what works for marketing potatoes in the long and short run using econometric models of potato demand in the retail and foodservice markets domestically, and in export markets.

What is an econometric model, and why are they useful? Econometric models are statistical methods that are able to identify the true causes of observed changes in demand when many things are changing at the same time: prices, incomes, tastes, demographics and, most important for the purposes of this study, marketing investment. Over the study period for this analysis, moreover, it was particularly important to control for the effect of the COVID-19 pandemic on demand, prices, and the returns to marketing. Econometric models answer the question: "if everything else is held constant, what is the independent effect of changes in advertising or promotion?" For immediate purposes, econometric models are useful because the 2002 Farm Security and Rural Investment Act (FSRIA) requires econometric analyses of federally-sanctioned marketing organizations every five years. More fundamentally, however, investment and allocation decisions are better informed when the stakeholders know what works and what does not, or what deserves more investment and what less. The models used here are designed with this purpose in mind.

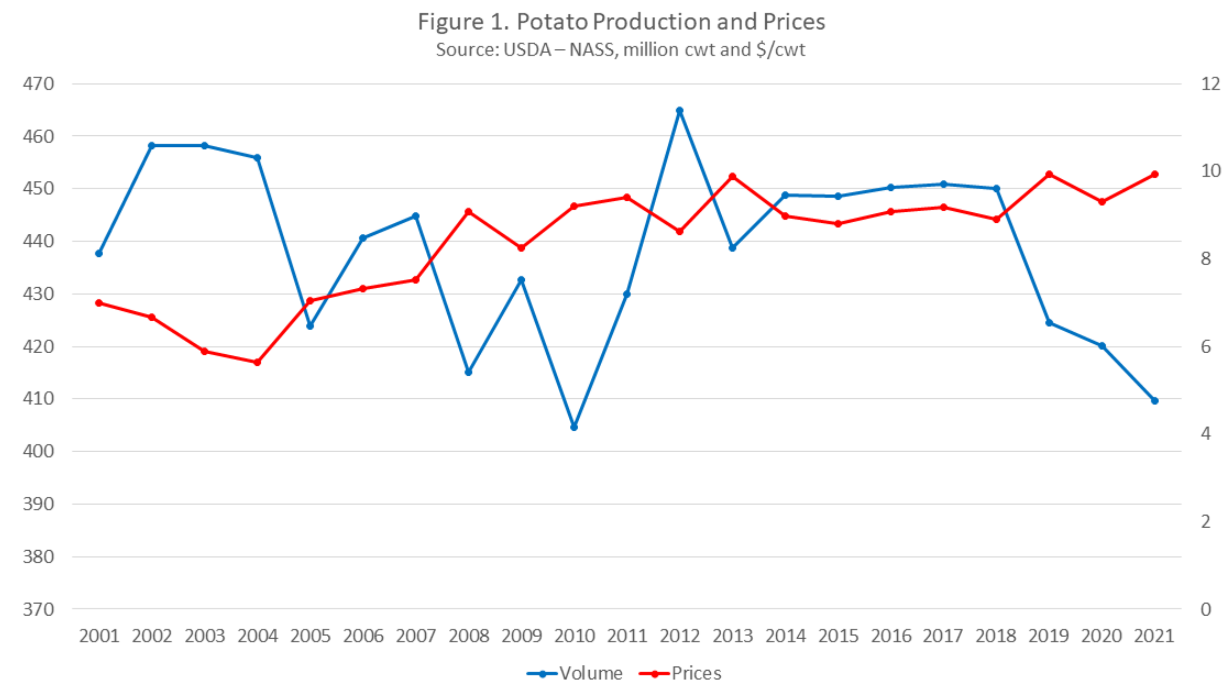
We also recognize that many investments made by Potatoes USA are long term in nature. Whether it is communicating nutritional messages, spreading the word about new menu items, or even building a strong web-presence, marketing investments are intended to "build the brand" as a long-term proposition. In this study, we estimate both the short- and long-term effects on demand of Potatoes USA activities, and define member returns to include both immediate impacts and those that may not be felt until several months in the future.

Objectives

The primary objective of this research is to estimate the long-run return on growers' investment in Potatoes USA marketing activity during the period 2016 - 2020 in both the domestic and export markets. To this end, our research encompasses a number of intermediate objectives. They are:

- To estimate the long-run impact of Potatoes USA marketing activities on the retail, foodservice, and export demand for all types of potatoes (product forms and packages) using a variety of econometric modeling techniques applied to scanner and shipment data.
- To determine the long-run impact of Potatoes USA marketing activities on retail and grower prices by developing models of each supply chain.
- To use the estimated demand effects at the grower level to calculate an expected annual increment to grower profit, the net present value of all future profit (net of program costs) and, ultimately, the return on investment (defined as the benefit:cost ratio, or BCR) due specifically to Potatoes USA marketing and research activities.

To achieve these objectives, retail sales data is essential in order to accurately measure the demand for potato products that may have changed in response to a particular marketing activity. In this respect, we have access to an ideal data set, made available by IRI (under contract through Potatoes USA), covering both perishable and center-of-store potato-product types. IRI "scanner" data measures all potatoes purchased through point-of-sale terminals at all retailers with greater than 2.0 million dollars in sales. The data include sales measured in both dollars and volume, which we use to impute a price per unit of volume. The data also includes a measure of the volume sold each week on promotion, which we use to control for the impact of price-promotions on retail volume. All retail sales data are available on a weekly basis over the entire sample period (2016 - 2020), and for a range of sub-categories, including fresh potatoes, potato chips, frozen potatoes, refrigerated potatoes, canned potatoes, deli potatoes, and



dehydrated products. While scanner data is not perfect, as it still leaves out smaller stores and some other that do not participate in the data syndication process, it remains the gold-standard for measuring demand at the retail level.

Data on foodservice movements proved more problematic. For evaluations in the past, conducted in 2012, Potatoes USA contracted with NPD, Inc. to acquire quarterly survey data of all potato products moving from manufacturers to foodservice outlets – restaurants, schools, hospitals, and the like. However, this PotatoTrac data was not available for either the subsequent analysis in 2016, nor the current analysis. In 2016, we used annual supply and utilization estimates prepared by Noedel Marketing for Potatoes USA, and imputed monthly variation in demand by assuming a similar seasonal movement as the retail data. For the current analysis, we did not have access to similar estimates, so we constructed a proxy measure of foodservice potato movement by subtracting retail and export shipments from USDA Market News Service monthly shipment data. While this measure is not perfect, we only require the resulting variation in residual market demand to be highly correlated with actual foodservice movements. Because all shipments have to go to either retail, foodservice, or export markets, we believe our assumption is valid. Further, because we did not have access to foodservice prices, we constructed an index of prices from the IRI scanner data, and used this as a proxy for the wholesale prices that foodservice buyers would have paid for each type of potato. While our approach is far from perfect, we are confident that it captures the trend in foodservice demand, and the effect of Potatoes USA marketing activities on that demand.

Data for the export-market component is less controversial. The United States Department of Commerce maintains a long-standing database of US imports and exports that are ideal for our purposes. By tracking both volumes and the value of trade, we are able to impute prices associated with annual volume movements to virtually any part of the world we may be interested in. Combined with measures of macroeconomic performance in each importing country (exchange rates, gross domestic product, and inflation), we are able to account for a large proportion of the observed variation in import demand. Typically, the independent effect of marketing investments are estimated with a high degree of precision in export markets.

Our measures of marketing intensity are drawn from Potatoes USA financial records, on a monthly basis, and represent the amount actually spent each month, as opposed to the amount budgeted. Although expenditures are available for a number of marketing categories (e.g., consumer and nutrition, retail, research, digital, foodservice, and administration) not all of these programs are intended to directly impact retail, foodservice, or export demand, as the case may be. Therefore, our econometric models include a measure of consumer-focused marketing activity, that aggregates consumer, nutrition, digital, foodservice, and retail expenditures into one investment category. This variable captures the bulk of monthly Potatoes USA spending, and nearly all that is intended to grow long-term demand.

As a technical matter, weekly prices in the retail model, and monthly prices in the foodservice model, are endogenous, meaning that they are determined at the same time as demand quantities. In other words, when prices and quantities change at the same time, it is impossible to disentangle the effect of marketing activities on demand without some way to independently control for price variation. For this purpose, we use input prices as instruments for the retail price. Specifically, we use prices on range of farm inputs, from chemicals to fuel, labor, and business services, in order to instrument for retail prices. All of these prices are taken from public data sources, including USDA-NASS and the Bureau of Labor Statistics.

All data analysis methods are well understood and accepted in the marketing-evaluation field and have been used extensively by the researchers.

In the next section, we describe the specific estimation methods used for each model, and we explain the economic logic behind our approach. Table 1 summarizes the marketing-budget data used in the analysis (Note: All values are in thousands of dollars per month, on average).

Demand Models

Overview

Marketing activities benefit grower-shippers by increasing demand, thereby raising surplus, or profit, on all potatoes sold. Therefore, modeling demand is at the core of any econometric analysis of the returns to commodity marketing. In this section, we describe in detail the three demand models estimated in order to achieve the goals described above: (1) a product-specific retail demand model, and (2) a foodservice demand model, and (3) an export demand model. In the following section, we describe how elasticity estimates from these demand models are used to calculate incremental profit, and return on investment.

Retail Demand for US Potato Products

The first model estimates the demand for each of seven different potato types (fresh, frozen, chips, refrigerated potatoes, deli potatoes, dehydrated potato products and canned items), disaggregated by 8 IRI regions in the US, on a monthly basis, from 2016 through 2020. In this model, the monthly volume sold of each potato product is assumed to be driven by its own price, a variable capturing the proportion sold on promotion, a set of regional, monthly and yearly fixed effects, lagged sales in each category, and a measure of marketing activity in the current month.

For current purposes, our measure of marketing activity is defined as simply dollar expenditures. While expenditures are not ideal for this purpose, they do represent valid proxy variables in an environment of relative price stability. Including lagged sales of each potato type accounts for the long-term effect of each demand-determinant through a "geometric lag" process. Intuitively, this mechanism implies that changes to each demand variable has a relatively large initial effect, but the effect declines slowly to zero over time. The time required for the effect to disappear entirely is known as the "adjustment period" for the model. The specific form of the model (a random-parameters log-log model) is well-accepted in the quantitative marketing literature, and regarded as perfectly valid for applied demand analyses such as this.

Our choice of these variables is guided by best-practices from the promotion-evaluation literature. As such, there are a number of fundamental principles that we capture with this econometric specification. First, advertising is expected to have a long-lasting effect on demand. Therefore, we differentiate between the short-run and long-run effects of both price and advertising as investments in "brand equity" are assumed to accumulate slowly over time. Second, advertising is subject to the principle of "diminishing marginal returns." That is, the more a particular medium is used, the less the incremental gain from an additional dollar spent on that medium so we assume marketing activities have a non-linear effect on demand. Third, marketing expenditures generally have differing effects for each type of product, so we allow for random marginal effects for each product type.

Marketing programs are an investment and not an expenditure, so are expected to have a lasting effect on consumers' perception of the product, and their likelihood of purchase. Whether this is through "brand" loyalty for a consumer good, "goodwill" to-

Table 1: *Budget Data Summary, FY 2016 - 2020, $ per Month*

Year	Retail	Consumer	Foodservice	MAP	Export
2016	$254,196	$189,023	$34,367	$377,563	$182,648
2017	$211,287	$164,840	$80,933	$347,049	$164,205
2018	$272,070	$229,192	$100,332	$354,154	$170,337
2019	$202,254	$166,751	$93,858	$350,647	$166,130
2020	$175,637	$141,344	$75,709	$350,305	$154,545

ward a commodity, or simply by contributing to consumers' stock of knowledge regarding the nutritional and taste attributes of a product, the effect of marketing activities both builds over time with additional expenditure, and decays as older campaigns are forgotten or abandoned. Being able to model the lagged-effects of advertising carefully is important as these competing effects likely differ in strength as time passes. For example, publishing the effects of new nutritional research results may result in an increase in demand only after a considerable amount of time has passed before consumers learn or truly understand the effect, while older research results may be forgotten or superseded by new results.

In order to capture the complexity of the dynamics involved in this process, we model each measure of marketing intensity using a geometric lag model. Simply put, a geometric-lag process is a flexible and parsimonious way to capture both long-term and short-term advertising impacts in an econometric model. We develop the geometric lag model more formally in the appendix.

Measures of the stock of advertising capital, or A_{ij} in the econometric model, typically comprise expenditure values for each marketing activity. Doing so is convenient because the estimated parameter provides a direct measure of the marginal or incremental effect of one more dollar of expenditure. We then measure the effectiveness of marketing investments on each potato type by calculating the marginal effect on sales volume per dollar spent in each area through the "advertising elasticity" metric. In this way, our method produces a direct measure of how the incremental, or "last dollar," of marketing expenditure influenced demand.

Price promotion is also likely to have a significant effect on demand. The retail data included a measure of the number of pounds sold on promotion, so we created a promotion proxy by calculating the proportion of volume in a given month sold on promotion, relative to total pounds. Including a measure of promotion activity is important, because we need to accurately measure consumers' response to changes in the everyday, "shelf" price in order to capture the true shape of the demand curve. If we did not include a measure of promotion, changes in the shelf price would be easily confused with temporary price reductions. In models of retail demand, measures of price-promotion typically capture a strong positive effect of temporary price reductions on demand. In fact, Potatoes USA marketing officials may be interested in these estimates as they extend their category-management partnership program with retailers throughout the US. Therefore, we expect to find a positive relationship between this variable, and the amount of monthly volume movement.

Casual inspection of retail potato sales data shows that they are subject to mild seasonality. Peaking at Thanksgiving, Christmas, and, to a lesser extent, Easter and the Fourth of July, this pattern is repeated reliably from one year to the next. Essentially, the demand curve shifts on a regular pattern from one season to the next, in a manner that is relatively consistent from year to year. Therefore, the econometric model is designed to represent this seasonality in a parsimonious and useful way. Specifically, we capture seasonality by including monthly fixed-effects, or simple binary indicators that allow the demand curve to shift during each time period, in the model.

Foodservice Demand

We estimate a second model of demand focusing on the foodservice market. Although foodservice, comprising not only restaurants, but schools, hospitals, prisons and other institutions, is an important market for potatoes of all types, Potatoes USA does not gather detailed data at any frequency above annual. Firms such as Technomic and NPD track consumers' away-from-home eating behaviors, but their data provides information only on whole-meal choices and total-bill prices. Consequently, we use monthly total potato shipments reported by the USDA-NASS Market News Service, as described above. These data are not ideal for our purposes, but are assumed to be a reasonably accurate measure of what is purchased by foodservice managers.

Foodservice purchases are what is known as a "derived demand," meaning that potato products are not purchased by the ultimate consumer, but by the restaurant or other organization that serves them. Therefore, the relevant price paid is the wholesale price. However, grower prices are not captured by Potatoes USA, nor by the USDA, at any frequency better than annual. Therefore, we use a monthly retail price index calculated from the IRI data above as a proxy for the wholesale price of foodservice potatoes. Because there are many types of potato and potato products purchased for foodservice uses, we construct a value-weighted index by dividing the total dollars spent by the volume purchased. This "unit value index" represents a reasonable proxy for the average price paid for foodservice potatoes.

In addition to the monthly price of foodservice potatoes, the foodservice demand model includes yearly indicator variables, regional and monthly fixed effects, and marketing investments. We account for the long-run effect of marketing investments in a method similar to that described above, that is, we allow for each type of expenditure to have an lasting effect through a geometric lag process. Essentially, a geometric lag simply means that the investment has its largest effect in the first month, and then declines geometrically for every month after that. In terms of the econometric model, a geometric lag is specified simply by including a one-period lagged value of the dependent variable (lagged quantity). We also account for the diminishing marginal returns to marketing investments by taking the log of each type of investment. We again combine all consuming-facing marketing expenditures, including those targeted to both retail and foodservice markets, and consisting of nutritional, research, and image messages, all defined on a monthly basis.

Algebraically, the foodservice and retail models are relatively simple, and are described more completely in the appendix below. In each, we regress the market share of each item on the set of explanatory variables described above. This log-log demand model has the advantage that each of the estimated parameters is interpreted directly as an elasticity. Elasticities of demand, in addition to the elasticities of supply and price transmission, are all that is needed to calculate the returns to potato marketing.

As with the retail model above, we estimate the foodservice demand model using instrumental variables methods to account for the fact that prices are likely to be endogenous, or determined simultaneously with the quantity demanded. Instruments for prices in both models are formed from a set of input prices (chemicals, fertilizer, energy and various services used to produce potatoes) as well as other variables that are determined outside of the demand model, such variations in the U.S. population, interest rates and lagged consumption values. These instruments explain much of the variation in prices and are independent of the equation errors *a priori*.

Export Demand

The data available for modeling US trade flows means that the set of products used in the international model differs from that used in either of the domestic models. Specifically, the export market model consists of four separate export demand equations for US potatoes: (1) fresh, (2) frozen, (3) dehydrated, and (4) seed potatoes.

To estimate the impact of Potatoes USA marketing activities, we use annual potato trade data obtained from the United States Department of Commerce, Foreign Trade Division (Harmonized Coding System, Schedule B). Potatoes USA export activity data were provided by organization staff, and include both USDA/MAP and private, or Board, expenditures on foreign market development activities. All expenditures are aggregated together into a single foreign market activity for each country/region.

For the fresh, and frozen export demand models, the following countries/regions were used: Japan, China, South Korea, Indonesia, Central America, Taiwan, Mexico, Thailand, Vietnam, Burma, the Philippines, and Malaysia. For the dehydrated potato export demand model, we used the same set of countries and regions, with the exception of Burma (Myanmar). The seed model also excludes Malaysia, Mexico, and the Philippines.

Macroeconomic data for each market and region are obtained from the USDA/ERS international macroeconomic database. The variables collected for each country/region include real Gross Domestic Product, agricultural adjusted exchange rates, and Consumer Price Indices.

As with the other models, the potential long-term impact of market development expenditures is estimated using a flexible, geometric lag specification.

The four export demand equations for US potatoes are estimated with (1) imports of US potatoes (fresh, frozen, dehydrated, and seed) as the dependent variable. These variables are measured on a volume basis (in metric tons) for each calendar year.

In each equation, import volumes are assumed to be a function of a set of explanatory variables. These variables include a measure of the price of exports, the level of economic activity in the importing country, a measure of consumer-price inflation, and a measure of the food-specific exchange rate.

First, we use a unit value index, or the price of each potato type, calculated by dividing the total value of US imports by the volume imported. Unit value indices are technically not prices, but are highly correlated with a trade-weighted index of export prices for each product. As such, they are readily accepted as proxies for export prices in the academic literature. The US price is expected to be negatively related to the volume of imports from the US in each country such that a lower price results in higher US import quantity demanded reflecting the law of demand.

Second, we include the quantity of annual potato exports from the US for each product in the proceeding year, or lagged import volumes. Exports in the previous year are included to capture dynamic effects of trade, perhaps due to trade rigidities, consumer preferences for potatoes with a US country-of-origin label, habits, or simply market inertia. For each of these reasons, exports from the US last year should be highly correlated with exports from the US this year.

Third, we include the average annual real (inflation-adjusted) GDP for each importing country/region, to capture variation in purchasing power in each importer. Purchasing power should be positively related to US potato exports, if potatoes are considered a differentiated or "luxury" product in each destination country.

Fourth, each model includes an average annual agricultural adjusted exchange rate (ER) of each importing country/region's currency per US dollar in order to reflect changes in exchange-rate adjusted prices. Exchange rates affect the true, or "landed" price of U.S. potatoes in each importing country, so are necessary to measure the true domestic-currency price.

Fifth, we include total annual Potatoes USA promotional expenditures, plus USDA/MAP foreign market development expenditures in each country. Although our data includes separate measures of MAP and Board expenditures, we combine them in the demand model as we assume consumers are not likely to be able to distinguish between them in the retail or foodservice market. To remove the effects of inflation on eroding promotion expenditures, US potato export promotion expenditures are deflated by the Consumer Price Index (CPI) in each importing region.

Similar to the other models, we estimate each model in log-log form, again with the desirable attribute that all estimated parameters are interpreted directly as elasticities. Although some countries do not import US potato products in all years, we assume these zeroes are "true zeroes" and do not represent a truncation in the import variable (due to other causes) that would otherwise bias our estimates. Further, initial estimates of the Seed model suggested that price was not significant, so was excluded from the final model.

Calculating Return

With the demand effects estimated above, we then calculate the return to marketing investments for each potato type. We use two, equivalent measures of return: (1) the benefit:cost ratio (BCR) and (2) the return on investment (ROI). BCR is calculated as the ratio of the present value of grower profit to the amount of investment. ROI is calculated as the ratio of the present value of the incremental gain in profit (producer surplus) generated by each program in the most recent fiscal year to the total amount of capital invested, or the cost of each type of marketing activity. Although the mathematical details of how incremental profit is calculated are in the appendix below, the intuition is straightforward.

Incremental profit is the present value of the difference between higher revenue generated from the increase in demand and higher production costs. BCR is expressed on a per-dollar-of-investment basis as it communicates how much profit each invested dollar is expected to generate. ROI is expressed on an annualized, rate of return basis in order to remain as comparable as possible to returns growers can expect on other investments, such as capital invested in their farms or in external capital markets. Because we estimate both short- and long-run demand elasticities, we estimate both short- and long-run changes in profit. In the long-run calculation, however, we also allow for the fact that growers are likely to increase the supply of potatoes in response to higher returns so we account for the "feedback effects" that are expected to result from a successful marketing program. Further, because the BCR / ROI estimate depends on the parameters of the producer surplus model (the elasticity of supply), we calculate BCR / ROI using a value for the supply elasticity taken from the literature on potato supply (Molina and Richards 2014).

Results and Discussion

Demand Models

Retail Demand Results

Retail demand was estimated using the econometric model described above. Based on the estimates from this model, we calculated response elasticities with respect to the retail price and marketing activities for all potato types, and summarize these elasticity estimates, both short-run and long-run, in table 2. Most importantly, the short-run price elasticity is approximately -0.42, which is substantially lower than in our previous studies (Richards 2012, 2016). Our elasticity estimate is relatively low because we aggregate over a large number of brands, package types, and product lines for each product type and elasticity estimates averaged over very specific product variants are, logically, much lower than when estimated for highly differentiated sub-aggregates. In particular, studies that do not distinguish between varietal demand are likely to miss the fact that consumers tend to substitute among products, so ignore an important source of demand variation. The fact that our current estimate is lower than the 2016 estimate, using exactly the same model, suggests that the demand for potato products is becoming more inelastic. This is a good thing for the US potato industry as inelasticity suggests greater price power, and less volatility of the quantity demanded by consumers to changes in producer costs. A price elasticity of -0.42 means that if price were to rise by 10 percent, the retail quantity demanded would fall by 4.2 percent, all else equal. In the long-run, the elasticity is slightly larger, at -0.46, with a similar interpretation.

It is also important to note the statistical significance, and economic impact, of price-promotion in the retail market. We found that price-promotion was the most significant determinant of retail demand, with a short-run elasticity of 0.081, and a long-run elasticity of 0.085. These estimates mean that increasing promoted volume relative to non-promoted volume by 10 percent can be expected to increase total sales (of both promoted and non-promoted potatoes), on average across all items, by about 1 percent. If the goal is to increase potato volume, price-promotion is clearly an effective tool to do so.

All of the marketing-mix elasticities were found to be statistically significant, and positive, which means that marketing activity for each product – independent of the other variables – had a positive effect on demand. In terms of the individual product elasticities, we found a short-run marketing elasticity for fresh potatoes of 0.037, and a long-run elasticity of 0.041. These estimates mean that a 10 percent increase in consumer-focused marketing investments can be expected to lead to a 0.37 percent increase in retail demand for fresh potatoes in the short run and a 0.41 percent increase in the long run. For frozen potatoes, we found a short-run elasticity of 0.025, and a long-run elasticity of 0.027. A larger response for fresh potatoes in the retail market may be an indication that effective messaging resonates most effectively with consumers who are willing to pay more for their fresh potatoes, and prefer to prepare their own potatoes at home, rather than buy a prepared, frozen product.

Table 2: *Retail Demand Model Estimates*

	Short Run	Long Run
Price	-0.4181	-0.4644
Marketing		
Canned	0.0170	0.0189
Dehydrated	0.0407	0.0452
Deli	0.0446	0.0496
Fresh	0.0370	0.0411
Frozen	0.0246	0.0273
Potato Chips	0.0386	0.0428
Refrigerated	0.0388	0.0431

In terms of the other processed potato products, we found a short-run marketing elasticity for potato chips of 0.039, and a long-run value of 0.043. Finding marketing to be slightly more effective for value-added items is perhaps not surprising because they are more highly differentiated in the retail market, generally branded (or private label) and have a higher unit value. Each of these characteristics is more conducive to effective advertising. Similarly, the marketing elasticities for frozen potatoes is 0.039 in the short-run and 0.043 in the long-run, while the estimate for refrigerated potatoes is 0.039 in the short-run and 0.043 in the long-run (these three items differ in elasticity at the fourth decimal place). We found an elasticity for dehydrated potatoes of 0.041 in the short-run, and 0.045 in the long-run, while for canned potatoes we found a short-run marketing elasticity of 0.017 and a long-run elasticity of 0.019. In general, our estimates across all potato types are remarkably similar, which may indicate that the mechanism underlying the activities employed has a similar effect on consumers of each different product.

Foodservice Demand Results

Like retail potato demand, foodservice demand was found to be inelastic with respect to prices (table 3) in both the short-run and the long-run. The short-run price elasticity of demand is -0.687 and the long-run price elasticity is -0.742. In general, foodservice demand is more elastic than retail demand because foodservice operators tend to be more attentive to cost, and substitute more freely across items or sources in order to meet a much larger volume-demand. Moreover, potatoes are a relatively large part of their budgets, so small changes in wholesale potato and potato-product prices are not easily overlooked. Moreover, finding a long-run elasticity that is substantially larger than the short-run elasticity is due to the fact that the rate of adjustment over time is relatively small, which means that quantity demanded adjusts to its long-run equilibrium value only slowly over time. For marketing purposes, however, it is the short-run price elasticity that matters as markets are always in a state of fluctuation and price changes in one month are nearly always superseded by changes in the following month.

Table 3: *Foodservice Demand Model Estimates*

	Short Run	Long Run
Price	-0.6869	-0.7420
Marketing		
Fresh	0.0468	0.0506
Chips	0.0375	0.0405
Frozen	0.0406	0.0438
Refrigerated	0.0422	0.0456
Dehy	0.0402	0.0434

Again, because foodservice demand is derived from what consumers are asking for at restaurants and other institutional settings, the same marketing variables are expected to move foodservice sales. In general, similar to the retail-model estimates, we find the response elasticities to be remarkably consistent among the different types of potato product. This is somewhat surprising, as we would expect the foodservice market to differ quite a bit from the retail market, simply because of the degree of separation between foodservice buyers and consumers. That is, consumers purchase potatoes as part of larger meals in foodservice environments, so their choices are mediated by professional chefs and purchasing managers, rather than making their own choices directly in retail stores. Professional preparation is also more important in a foodservice setting, so while consumers may not try to prepare a dish at home, they would try it if someone else, professionally trained, were to make it for them.

In terms of the responsiveness of individual products to marketing investments, we find that fresh potatoes are the most responsive, with a short-run elasticity of 0.047, and a long-run elasticity with respect to marketing dollars of 0.051 (table 3). Refrigerated potato products are only slightly less responsive (short-run = 0.042 and long-run = 0.046), followed by frozen (short-run = 0.041 and long-run = 0.044) and dehydrated products (short-run = 0.040 and long-run = 0.043). The elasticity of chip demand with respect to marketing is lower, with a short-run response of 0.038 and a long-run response of 0.040. In general, however, these elasticities are all statistically significant, positive, and in a range that is considered to be highly effective based on sales-response alone.

Note that the gap between the short-run and long-run estimates is not particularly large, especially when compared to previous analyses of the potato market (Richards 2012, 2016). The relatively small gap between short-run and long-run estimates means that advertising investments of all types are not expected to have a lasting effect in the foodservice market, relative to what we found before. Although we cannot test any specific mechanisms that may explain why the market seems to be discounting the long-run effect of advertising, it may be due to the increasingly competitive nature of the food market more generally. In other words, if competing products advertise - whether online or elsewhere - more aggressively than they have in the past, then we would expect to see the result show up as own-advertising effects deteriorating more quickly over time. Regardless, our elasticity estimates should be of value in allocation expenditures across potato products, although our primary interest in estimating them is to use them as inputs to the returns-calculation model. We present these results next.

Export Demand Results

We estimated the import demand models for fresh, frozen, dehydrated and seed potatoes in logarithmic form with annual data from 2016 through 2020 for the list of importing regions mentioned earlier in this report. In table 4, we report the elasticities that are of interest to our objectives here, estimated holding each of the other explanatory variables constant. For all variables, the elasticity signs are consistent with economic theory, and the majority of estimated coefficients are statistically significant.

Table 4: *Export Demand Model Estimates*

	Short-Run	Long-Run
Price		
Frozen	-2.8880	-3.8381
Fresh	-1.9447	-2.0825
Dehy	-2.1191	-4.5293
Seed	N.A.	N.A.
Marketing		
Frozen	0.0057	0.0076
Fresh	0.0392	0.0420
Dehy	0.0543	0.1161
Seed	0.1402	0.1683

Not surprisingly, the price of US potatoes is a significant factor in explaining annual variations in imports in the first three models (frozen, fresh, and dehydrated potatoes). The estimated short-run own-price elasticities for frozen, fresh, and dehydrated potatoes are -2.888, -1.945, and -2.119 respectively, indicating that a 1% increase in the US price would decrease imports by 2.888%, 1.945%, and 2.119% in the short-run, holding all other demand determinants constant. The long-run own price elasticities for these three products are -3.838, -2.083, and -4.529, respectively. Relative to the estimates for either of the domestic models, therefore, it is clear that export demand is substantially more elastic, particularly in the long-run. One explanation for this finding is that importers have more alternatives for their potatoes than do domestic consumers, so if the price changes, they are able to more readily substitute to potatoes from another source.

As in the domestic models, our estimates provide statistical support for the effectiveness of US potato export promotion programs, which are funded by public-private contributions. In fact, the estimates in table 4 show that Potatoes USA marketing efforts have the effect of increasing the export demand for all types of US potatoes. The estimated short-run export promotion elasticities for frozen, fresh, dehydrated, and seed potatoes are 0.006, 0.039, and 0.054, and 0.140, respectively. That is, holding all other demand factors constant, a 1% increase in US potato export promotion expenditures would result in a 0.006%, 0.039%, and 0.006% increase in imports of US frozen, fresh, dehydrated, and seed potatoes in the short-run. The long-run export promotion elasticities for these products are: 0.008, 0.042, 0.116, and 0.168, respectively. Although each of these elasticities suggests that Potatoes USA increases the demand for US potatoes abroad, whether the increase in demand is sufficient to cover the cost of each program depends on the resulting change in price, and profit, to US growers.

Returns to Marketing Investments

Overview

In this section, we present and explain the returns to marketing investments for each product in the retail, foodservice, and export channels. Further, due to the long-term nature of marketing investments, we calculate the present value of incremental profit over the sample period and report both BCR and ROI measures.

Taking into account the entire future stream of profit due to an investment in each period is important because any marketing investment is expected to have long-term demand effects. Our calculations provide estimates of the marginal return, as opposed to the average, as growers and shippers are interested in the return on the next dollar invested when making budget allocation decisions. In this study, we calculate BCRs and ROIs for marketing activity for each type of potato product in the retail, foodservice, and export markets over a range of possible supply elasticities, from 0.25 to 1.5 with the most-likely value 1.0, and report the most-likely BCR values in table 5 below. The ROI values show a similar pattern, so are not included in the table. In general, returns fall as the elasticity of supply rises (price effects are muted with more elastic supply) and, given that empirical estimates of most commodity-supply elasticities are substantially lower than 1.0, our estimates are relatively conservative.

Returns in the Retail Market

From the results reported in table 5, we see that marketing activities generate positive returns for all products in the short- and long-runs as all BCR values are above 1.0. Recall that a BCR greater than 1.0 means that an activity generates more dollars in incremental value (present value of future profit) than the investment cost. A BCR of exactly 1.0, however, generates a rate of return (ROI) of 0 percent, which is not likely above growers' opportunity cost of capital. Therefore a BCR of 1.05 or greater (ROI of 5 percent) should be interpreted as covering the cost of the investment, and a conservative estimate of growers' cost of capital. With respect to individual product-types, the estimates in table 5 show that investments in the retail market generate BCRs that

Table 5: *Retail and Foodservice BCRs*

	Short Run	Long Run
Retail		
Canned	1.0618	1.1334
Dehydrated	2.5419	2.7132
Deli	2.7900	2.9781
Fresh	2.3118	2.4677
Frozen	1.5353	1.6388
Potato Chips	2.4106	2.5731
Refrigerated	2.4271	2.5907
Foodservice		
Fresh	3.5973	3.7396
Chips	2.8831	2.9972
Frozen	3.1170	3.2404
Refrigerated	3.2444	3.3727
Dehy	3.0898	3.2121

are generally favorable, but only marginally in the case of canned potatoes (short-run BCR = 1.062, ROI = 6.18%, long-run BCR = 1.133, ROI = 13.3%). Each of the other products generate BCRs that are solidly positive. For example, in the case of dehydrated potatoes, the short-run BCR is 2.542 (ROI = 154.2% percent), and 2.713 (ROI = 171.3%) in the long-run. In other words, funds invested in marketing activities generate 2.542 dollars of incremental profit in the retail market for every dollar invested in the short-run, but 2.713 dollars in the long-run. Equivalently, the ROI estimates imply that the same investment would be viable with virtually any reasonable hurdle rate of return in either the short- or long-runs. To put this into perspective, if the cost of capital for a typical grower is in the range of 5.0 - 7.0 percent, a 154.2% ROI generates a very substantial surplus return. Because most producers are presumably invested for the long-run, for practical purposes the long-run estimate is more meaningful, and suggests that investments in retail marketing are highly profitable.

Returns to other product-types in the retail market show a similar pattern, and generally higher returns than the canned potato case. In the short run, the BCR for deli potatoes is 2.790 (ROI = 179.0%), while the long-run BCR is 2.978 (ROI = 197.8%). As in the deli potato case, any BCR greater than 1.0 more than covers the initial investment, while a ROI value greater than a typical grower's required rate of return increases the value of his or her operation. Both measures of return are higher than the estimated return to marketing fresh-bagged potatoes, so are strongly positive. The returns to other products are similarly strong. In the short-run, the BCR for fresh potatoes is 2.312 (ROI = 131.2%), while the long-run return is 2.468 (ROI = 146.8%). For frozen products, the returns are slightly lower than in the fresh market, as the short-run BCR is 1.535 (ROI = 53.5%) and is 1.639 (ROI = 63.9%) in the long-run. Chips show a short-run BCR of 2.411 (ROI = 141.1%) and a long-run BCR of 2.573 (ROI = 157.3%) and the returns for refrigerated products are 2.427 (ROI = 142.7%) in the short-run and 2.591 (ROI = 159.1%) in the long-run. In the retail market, the gap between short- and long-run returns is relatively small because the price adjustment necessary to re-equilibrate supply and demand following a shock to demand is rapid.

Returns in the Foodservice Market

In the foodservice channel, we find generally higher returns to consumer-facing marketing activities than in the retail channel. Despite the fact that consumer decisions are filtered through foodservice-buyers in this channel, we interpret this finding as implying that buyers anticipate higher demand from effective marketing programs, and buy accordingly. The estimates in table 5 suggest that consumer-focused marketing has an expected BCR for fresh potatoes of 3.597 (ROI = 259.7%) in the short-run and a BCR of 3.740 in the long-run (ROI = 274.0%). Processed items in the foodservice market tend to exhibit moderately lower returns as the short-run BCR for chips is 2.883 (ROI = 188.3%) and is 2.997 in the long-run (ROI = 199.7%). The BCR for frozen potatoes is also high at 3.117 in the short-run (ROI = 211.7%), and 3.240 in the long-run (224.0%). The return to marketing refrigerated potatoes is similar, at 3.244 in the short-run (ROI = 224.4%), and 3.373 in the long-run (ROI = 237.3%). Finally, the return to dehydrated potatoes is strongly positive in both the short- (BCR = 3.090, ROI = 209.0%) and long-runs (BCR = 3.212, ROI = 221.2%). In general, therefore, Potatoes USA marketing is highly effective in the foodservice market, subject to the caveat that our data for this analysis was not perfect. Again, if growers are accurately assumed to be invested for the long-term, it is only the long-run return values that are of concern to Committee stakeholders.

Returns in the Export Market

Returns to export market development were calculated using the same procedure as in the retail and foodservice examples described above. Because we only have 5 years of data available, however, to estimate the increment in grower profit from sales into the export market, it is necessary to assume that sales to each country have the same effect on grower demand, and supply, as domestic sales. Conceptually, we believe this assumption is valid as a rise in export-market potatoes represent a similar shift in demand to a rise in demand for either retail or foodservice markets.

The profit-calculation model is simulated using the same set of supply-chain assumptions as the previous models. That is, we assume the increment in demand due to the estimated export-market promotion elasticities in table 4 causes equilibrium prices to rise in the domestic market, which causes profit to rise after accounting for the higher cost associated with firms moving up their supply curves. The incremental farm profit is then expressed as a ratio to the cost of the program in order to arrive at an estimated BCR. All of these calculations are again conducted on a present-value basis as we account for both the short- and long-run effects of export market promotion. The estimated returns are shown in table 6 below.

Table 6: *Export Market BCRs*

	Short-Run	Long-Run
Frozen	1.5503	1.6310
Fresh	2.0098	2.0464
Dehy	2.0093	2.3232
Seed	1.2832	1.3425

For our assumed supply elasticity, the BCRs are significantly larger than 1.0, indicating that the benefits of export promotion are larger than the costs. For example, based on a supply elasticity of 1.0, which is probably the most plausible estimate for potato exports, the long-run BCRs for frozen, fresh, dehydrated, and seed potato export promotion are 1.631, 2.046, 2.323, and 1.343, respectively (ROI = 63.1%, 104.6%, 132.3% and 34.3%). These are indeed high returns relative to the opportunity cost of stakeholder capital, but are generally lower than returns in the domestic market. If our estimates are correct, they suggest a reallocation of efforts toward either retail or foodservice markets, and away from export promotion. Expressed differently, the benefits of export promotion in terms of the marginal dollar investment returned 1.631 dollars, 2.046 dollars, 2.323 dollars, and 1.343 dollars in profits. The overall BCR for all four programs is 1.836, based on the supply elasticity of 1.0. Based on the average of these BCRs, it appears that dehydrated potato export promotion offered the highest return on investment followed by fresh, then frozen, and finally seed potato export promotion.

Summary of Returns

In summary, we find that Potatoes USA marketing programs are profitable for all product-types in both the short-run and the long-run (BCR greater than 1.0). Interpreted as returns on the last dollar spent, our results suggest that potato production and marketing would be significantly more profitable if more dollars were allocated to the activities with the highest return. If marketing budgets are fixed, then our findings suggest re-allocating funds toward foodservice promotion, specifically for fresh and refrigerated potatoes, in the domestic market, and fresh and dehydrated potato products in the export market.

Conclusions and Recommendations

Total potato shipments in the US declined slightly over our study period, but generally higher prices could have explained some of the decline. Further, our study period coincided with perhaps the greatest shock to consumer-product markets in a generation: The COVID-19 pandemic. To account for both higher prices and the COVID-19 disruption, statistical analysis is necessary to determine the independent effect of Potatoes USA marketing on demand. This study uses data from 2016 - 2020 to investigate the return on investment for grower-shipper dollars invested in all Potato USA marketing activities, on a product-by-product basis. Because many factors other than marketing activities can explain changes in demand over time, the specific role of Potatoes USA in helping maintain consumer demand is an important, and empirical question.

We find that all Potatoes USA activities were effective in raising demand when controlling for the effect of prices, seasonality, changes in production conditions and other factors relevant to the demand for fresh potatoes and processed potato products. Among the different markets considered, we found that marketing efforts were particularly profitable for fresh and refrigerated potatoes in the foodservice market, and fresh and dehydrated potato products in the export market. Deli and dehydrated potatoes responded the most to programs targeting the retail channel, although the differences between products were very small. No product-types exhibited negative rates of return, either in the short- or long-runs.

In arriving at these conclusions, we recognize that the quality of our findings are inevitably limited by the quality of the data. While the IRI data describing retail sales of retail potatoes are widely regarded as accurate and useful for this purpose, there is less certainty regarding the value of the USDA-NASS data used for the foodservice market. Future evaluations of this type would benefit greatly from direct measures of consumption – and prices – for potatoes sold into the foodservice market. This recommendation is particularly relevant given the importance of the foodservice market both in terms of the overall dollar sales level and "at the margin," or the changes in shipments from month to month that have a magnified effect on prices.

Appendices

Appendix 1. Retail Demand Model

This appendix describes in more detail the specific econometric models that are used in estimating the impact of Potatoes USA marketing activities on the demand for various types of fresh potato and potato products in the domestic retail and foodservice markets. For this analysis, it is assumed that the market segments are independent so we estimate separate models for each.

In this appendix, we use the retail market model (estimated using IRI data) as an example. Implicitly, by using this model we assume retail potatoes are differentiated by product-form (fresh, frozen, chips, refrigerated, canned, deli, and dehydrated). As such, an individual consumer is assumed to choose only one product from all other substitutable products available to them on that particular trip to the store. Consequently, we represent the demand for retail potatoes with a discrete choice model of differentiated product demand (Berry 1994; Berry, Levinsohn and Pakes 1995; Nevo 2000). We begin by defining a random utility representation of individual household demand, and then aggregate over the distribution of consumer heterogeneity to arrive at a consistent aggregate demand for potatoes in the market as a whole. We write the utility for household h as:

$$u_{hj} = v_{hj} + \epsilon_{hj} = \beta_{0j} + \sum_k \beta_{1k} x_{jk} + \sum_l \gamma_l f(A_1) - \alpha p_j + \xi_j + \epsilon_{hj}.$$

where β_{0j} is the maximum willingness to pay for potatoes of type or variety j, p_j is the retail price of product j, x_j is a set of other explanatory variables, including price-promotion, personal income, seasonality, regional effects, and other indicators to account for other non-quantifiable factors that may affect potato sales, $f(A_1)$ is the stock of marketing capital created by investments in marketing activity l by the MC, ξ_j is an unobservable (to the econometrician) error term and ϵ_{hj} is a random error, assumed to be iid extreme value distributed. Household h will choose the product of type j if the utility from this choice is greater than the utility from all other alternatives. In other words, the probability that household h chooses j over all others is governed by the distribution of ϵ_{hj} because:

$$\begin{aligned} Pr(j = 1) &= Pr(v_{hj} + \epsilon_{hj} > v_{hi} + \epsilon_{hi}) \\ &= Pr(v_{hj} - v_{hi} + \epsilon_{hj} > \epsilon_{hi}). \end{aligned}$$

As is well understood, if ϵ_{hj} is distributed extreme value, the random utility model in this equation implies share functions for each product of type $j = 1, 2, ..., J$ of:

$$S_j = \frac{\exp(v_{hj})}{1 + \sum_{i=1}^{I} \exp(v_{hi})}$$

where S_j is the market share of product type j. This expression yields the multinomial logit (MNL) model of discrete choice used by Berry (1994), Nevo (2001) and many others to study the structure of demand for differentiated products. Although the simple MNL model in this equation suffers from the proportionate draw problem (also called the "independence of irrelevant alternatives, or IIA problem), meaning that the cross-elasticities for all alternatives are equal, the IIA problem is of little consequence in this application. Promotion effectiveness depends on the own-price and marketing-elasticity and, to a much lesser extent, on the cross-price elasticity. Consequently, the degree of error caused by the IIA simplification is likely to be very low.

Our primary interest in estimating these equations lies in obtaining price and marketing elasticities. Elasticities are derived from the MNL model by finding the derivative of the share function in price (marketing) and multiplying by the ratio of price (marketing capital) to the mean share. The resulting expressions are given by:

$$\epsilon_{p_j} = (\partial S_j / \partial p_j)(p_j / S_j) = \alpha \bar{p_j}(1 - \bar{S}_j),$$

in price, and:

$$\epsilon_{A_{jl}} = (\partial S_j / \partial A_l)(\bar{A}_l / \bar{S}_j) = \gamma_l \bar{A}_l (1 - \bar{S}_j)$$

in marketing capital. Evaluating each elasticity specific to each product type provides valuable information on the differential effect of price changes and marketing investments on sales of each potato product. These response parameters form the key input to the profit calculation model described below.

Appendix 2. Returns Calculation

This appendix describes the way in which we will calculate the increment to total grower profit given the impact parameters estimated according to the procedure described above. This model is similar to one used in Richards and Patterson (2000) and was originally developed by Kinnucan et al. (2000). To calculate profit, the analysis takes into account: (1) the activity impact on demand quantity (retail or foodservice), (2) the impact on price, (3) the feedback effect of higher prices on market supply, and (4) the transmission of retail prices to the grower level. Although the final solution consists of a single equation, the model requires separate components for each element (1) to (4). Again in mathematical terms, this model, written in terms of the change in the log of each variable value, appears as:

$$\begin{aligned} d\ln\mathbf{Q_r} &= \mathbf{N_r}d\ln\mathbf{P} + \mathbf{G}d\ln\mathbf{Z_r} + \sum\mathbf{B_j}d\ln\mathbf{A_j} \\ d\ln\mathbf{X} &= \mathbf{E_s}d\ln\mathbf{W} \\ d\ln\mathbf{W} &= \mathbf{T}d\ln\mathbf{P} \\ w_r d\ln\mathbf{Q_r} &= d\ln\mathbf{X}, \end{aligned}$$

where the first equation represents the effect of marketing investments on demand, the second is the effect on output supply, the third measures the rate of price-transmission from retail to the farm-gate, and the fourth is the market equilibrium identity. Each equation is then substituted into market equilibrium to solve for the resulting price impact of the marketing program:

$$d\ln\mathbf{P} = \mathbf{M}^{-1}\mathbf{G}d\ln\mathbf{Z_r} + \sum\mathbf{M}^{-1}\mathbf{B_j}d\ln\mathbf{A_j},$$

Given this change in prices, the addition to profit is then calculated as:

$$d\pi \;=\; \sum_i S_i^f P_i Q_i d\ln W_i(1 \;+\; 0.5d\ln X_i),$$

where the subscript indicating activity l has been suppressed for clarity. Each of the variables and parameter values are defined as follows: $\mathbf{W}$ = variables representing FOB (grower) prices for each product, $\mathbf{X}$ = variables representing supplies of each product, $\mathbf{P}$ = variables representing market prices, $\mathbf{Q_r}$ = variables representing retail and food service quantities, w_r = share of market in retail or food service, S_{if} = grower's share of the retail dollar for the i^{th} product type, $\mathbf{Z_r}$ and $\mathbf{Z_x}$ = factors affecting demand in retail and food service markets, $\mathbf{A_j}$ = variable representing marketing activity j, $\mathbf{N_r}$ and $\mathbf{N_x}$ = groups of retail and import demand price-response terms, $\mathbf{B_j}$ = response measures for the k^{th} type of activity, $\mathbf{T}$ = price-transmission elasticities (percent of price going to grower), $\mathbf{G}$ = demand elasticities with respect to exogenous retail factors, E_s = supply response elasticities, $\mathbf{M} = \mathbf{E_s}\mathbf{T} - w_r\mathbf{N_r}$ = solution for the change in price variable. While values for most of these variables are estimated in the relevant demand model, the supply-response elasticities, price-transmission elasticities and growers' share of the retail dollar are not. First, reliable estimates of the elasticity of supply are difficult to come by and are not estimable with the data at hand. Therefore, we calculate the return to each marketing activity under a range of supply elasticities from 0.25 to 1.5. Based on previous research for other commodities, however, it is determined that a supply elasticity of 1.0 in the long run is the most likely. This means that a 10 percent increase in the grower price is likely to lead to a long run increase in the supply of potatoes of 10 percent. Second, the price-transmission elasticity is calculated using the formula in Gardner (1975) as:

$$\mathbf{T} \;=\; \frac{\mathbf{E_b}}{S_f\mathbf{E_b} \;+\; (1 \;-\; S_f)\mathbf{E_s}},$$

where E_b is the elasticity of supply of non-farm inputs, which is assumed to equal 1.5. Third, ERS-USDA reports the farm share of the retail dollar for all vegetables as 0.255. Given that we have access to both retail and grower prices (USDA-NASS), we sought to corroborate this value by estimating a "pass-through elasticity," which is the responsiveness of grower prices to changes in retail prices. Using regression models similar to those described above, we estimated a pass-through elasticity of 0.29, which means that for every 10 percent change in the retail price, the grower price changes by 2.9 percent. Our estimate was highly statistically significant, meaning that we are very confident that this estimate is close to the true value. Therefore, we adopt this value as an approximation of the share of each retail dollar earned by potato growers. This model, while appearing quite complicated, is easily implemented with any spread sheet or data base software. Based on the incremental profit calculated in the model above, the net present value of investment in activity l is calculated as:

$$NPV_l = \sum_{t=1}^{40} \exp(-rt) d\pi_l - c_l,$$

where $\exp(-rt)$ is the "present value factor" that is used to calculate the present value of incremental operating in month t at time 0 at a discount rate r, c_l is the amount of expenditure on activity l and summing over a sixty month period reflects the assumed long-range planning horizon of Potatoes USA. If NPV_l is greater than zero at an interest rate that reflects Potatoes USA members' opportunity cost of capital, then investments in activity l are economically viable.

References

[Berry, 1994] Berry, S. (2000). Estimating discrete-choice models of product differentiation *RAND Journal of Economics*, 25:242–262.

[Kinnucan Xiao Yu, 2000] Kinnucan, H. W., Xiao, H., and Yu, S. (2000). Relative effectiveness of USDA's nonprice export promotion instruments. *Journal of Agricultural and Resource Economics*, 25:559–577. Nevo, A. (2000). A practitioner's guide to estimation of random-coefficients logit models of demand. *Journal of Economics and Management Strategy*, 9:513–548.

[Richards and Patterson, 2000] Richards, T. J. and Patterson, P. M. (2000). New varieties and the returns to commodity promotion: the case of Fuji apples *Agricultural and Resource Economics Review*, 29:10–23.