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Economic Impacts of Increasing the Minimum Size for Idaho Fresh Potatoes

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Abstract

The Idaho Potato Commission funded a project to help answer the question: What would be the economic impact if the potato industry increased the minimum size for fresh potatoes? We estimate that increasing the minimum size from 4 to 5 ounces would divert about 5 million hundredweight (cwt) to dehydrators. Idaho fresh potato revenue would increase \$73 million. Idaho dehydrated potato revenue would increase \$18 million. The total impact would be increased revenue of \$91 million. A sensitivity analysis showed that revenue increases are larger when more potatoes are diverted.

Keywords: fresh potatoes, dehydrated potatoes, size standards

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Introduction

Market Situation

The Idaho fresh and dehydrated potato industries are closely linked. Growers deliver bulk potatoes to fresh packers who sort them into two main categories. Packers put the 4-8 ounce potatoes into five- and ten-pound bags known as 'consumer packs' for sale in retail markets. Larger potatoes are put into 50-pound cardboard boxes known as 'count cartons' and are sold in both retail and foodservice markets. Potatoes that are less than four ounces and those that do not meet fresh-market standards because they are cut, bruised, blemished or misshapen are sold to dehydrators.

A typical pack-out rate for Idaho's most popular potato variety—the Russet Burbank, is 60% fresh and 40% dehydration. Dehydrators rely on this fresh packer by-product, known as Washed Processed Grade (WPG), as a major source of raw product. The processors convert the potatoes to flakes and granules for three market channels. In addition to foodservice and retail markets, dehydrated potatoes go to other food processors, including snack food firms that make extruded chips such as Pringles®.

The fresh potato industry uses two price indexes to communicate price information. At the packer level, the Fresh Weighted Average (FWA) accounts for typical fresh pack-out rates and current prices for different sizes and containers. The North American Potato Market News (Huffaker 2011) reports weekly FWA prices based on (1) consumer packs in 10-pound bags, (2) 50-pound cartons of 40, 50, 60, 70, 80, 90, and 100 counts and (3) US #2 potatoes. Each package has a respective weight in the formula. At the grower level, the Grower Return Index (GRI) accounts for the FWA pack-out plus WPG prices and a packing charge. Changing the minimum size standard would impact pack-out rates and prices. The Agricultural Marketing Agreement Act of 1937 allows the Idaho potato industry to set quality standards and they do it through Federal Marketing Order 945. Changing the standard would require approval by two-thirds of the Idaho growers and the US Secretary of Agriculture. Growers in Colorado and other regions sometimes change their minimum size requirements based on current crop conditions, weather challenges, and market strategies while Idaho has maintained consistent standards.

The Idaho Potato Commission (IPC) promotes Idaho potatoes through advertising, public relations and quality control. As a result, Idaho fresh potatoes have long sold for price premiums that more than offset transport cost differences. Idaho's price premiums have been partly related to grade requirements that are higher than USDA standards. For example, USDA requires a 1-7/8 inch minimum size, while Idaho has used 2 inches or a 4-ounce minimum. In recent years Idaho's price premiums have shrunk and sometimes disappeared. Seeking answers for the price premium erosion, IPC asked University of Idaho faculty to analyze the economics of increasing minimum size requirements for fresh Idaho potatoes.

Diversion

Increasing the minimum size for fresh Idaho potatoes would cause a diversion from one market to another. Several researchers addressed the issue of agricultural product diversion. Nguyen and Vo (1985) and Price (1967) analyzed the economics of discarding low quality produce. Bockstael (1984) claimed that diverting off-grade product from fresh to dehydrated markets would benefit consumers in the secondary market due to lower prices, but net social welfare would decline. IPC is more interested in the producer benefits of diversion. Minami, French, and King (1979) found that volume controls via marketing orders increased grower profits in the California peach industry. Saitone and Sexton (2008) showed that marketing order enforcement of minimum quality standards benefit producers who divert from a market with inelastic demand to a market with elastic demand.

A number of researchers concluded that demand for fresh potatoes is inelastic. Guenthner, Levi & Lin (1991) estimated an elasticity of -0.14 for US fresh potatoes in retail markets. Miranda and Glauber (1993) calculated fresh potato elasticities ranging from -0.52 to -0.27 depending on the time of year. Richards, Kagan, and Gao (1997) estimated fresh potato price elasticity at -0.48. Babula, McCarty, Newman, and Burket (1998) used monthly data from 1987 to 1996 to conclude that price elasticity of fresh potatoes is between -0.30 and -0.50. Greenway, Guenthner, Makus and Pavek (2011) found elasticities of -0.60, -0.65 and -0.75 for red, russet and organic potatoes.

Objectives

The overall objective is to estimate the impacts of increasing the minimum size standard on Idaho potato industry revenue. To accomplish that, the specific objectives are to estimate:

1. quantity of potatoes that would be diverted from fresh to dehydrated
2. impact on fresh packer revenue
3. impact on dehydration processor revenue

Methods

Quantity

We used data from the Idaho Agricultural Statistics Service (2011) to determine the amount of fresh potatoes that would be diverted as a result of the minimum size increase. IASS conducts annual random field digs to estimate the grade and size profile of each Idaho potato crop. The data is available for five areas: Southwest, South Central, Eastern, Eastern seed counties (high elevation counties in Eastern Idaho), and other counties. We chose the Eastern region as most representative of the Idaho fresh potato industry for this study. It consists of Bannock, Bear Lake, Bingham, Bonneville, Franklin, Jefferson, Madison, Oneida, and Power counties. IASS provides annual data for thirteen size categories ranging from 1½ inches to 14 ounces & over.

Fresh Market

Monthly Model

We attempted to build a monthly model, using ordinary least squares (OLS), to estimate an inverse demand function:

$$P = f(Q_{ID}, Q_{US}, S_{ID}, S_{US}, I, A, Q_i)$$

Where:

P = price of fresh Idaho potatoes (\$/cwt)

Q_{ID} = quantity of fresh Idaho potatoes shipped (million cwt)

Q_{US} = quantity of fresh non-Idaho US potatoes shipped (million cwt)

S_{ID} = stocks of Idaho potatoes in storage (million cwt)

S_{US} = stocks of non-Idaho US potatoes in storage (million cwt)

I = disposable personal income per capita (\$1000 deflated by CPI)

A = binary variable to depict an increase in advertising funding in 2007

Q_i = binary variables for three quarters of the year (base Q4).

Our period of analysis was 120 months from August 2000 to November 2010. We obtained data on Idaho fresh potato prices and shipments from the Federal State Market News Service (2011). The formula for the fresh weighted average (FWA) price came from a potato market analyst (Huffaker 2011). The Bureau of Labor Statistics (2011) provided consumer income data. The Idaho Potato Commission was the source of advertising information.

When we chose variables, we considered Tomek and Robinson's (1990) four demand shifters: U.S. population; income; other goods and tastes & preferences. Since population changed little during the period of analysis we did not include it in the model. The other three demand shifters are represented by the explanatory variables. Since Greenway et al. (2010) found that the best substitute for potatoes is other potatoes, we included non-Idaho potatoes in the model. The advertising variable is a proxy for consumer tastes and preferences. It has a value of 0 for all months before 2007 and a value of 1 beginning with the 2007 crop. That is when IPC, bolstered with increased funding, switched from regional to national advertising.

We expected negative coefficients on the monthly shipments and stocks variables. Hypothesizing that fresh potatoes are an income-inferior good (consumption drops when income increases) we expected a negative sign for income. Increased advertising should have a positive impact on consumer tastes and preferences and therefore a positive coefficient sign. We hypothesized that potato prices would follow a seasonal pattern. The fourth quarter (October – December), when most potatoes are harvested, was when we expected the lowest average price. We thought that the first, second and third quarter dummy variables would have positive signs due to increasing storage costs during the marketing season.

Annual Model

Due to poor results with the monthly model, we developed a simple annual model. The idea came from a potato market analyst who uses a fresh potato price forecasting model consisting of

two explanatory variables: fresh potato shipments and changes in total potato production (Huffaker 2011). Our annual model, estimated by Ordinary Least Square (OLS), is specified as:

$$P = f(Q_{ID}, \Delta Q_{US})$$

Where:

P = Idaho fresh weighted average (FWA) price divided by the consumer price index (\$/cwt)

Q_{ID} = is the quantity of fresh Idaho potatoes shipped divided by US population (lb/person).

ΔQ_{US} = is the change in the quantity of all US potatoes produced (%)

The period of analysis was the 21 crop years from 1990 through 2010. The source of the price data was United Potato Growers of Idaho. The Federal State Market News Service provided the fresh shipment data and the potato production data came from USDA NASS. All potato price and quantity data was for the August through July crop year used by USDA. US population and CPI data came from the US Census Bureau (2011) and US Bureau of Labor Statistics (2011).

From the fresh potato demand equation we estimated price flexibility. We used the quantity of fresh potatoes to be diverted along with the price flexibility to estimate changes in Idaho potato shipper revenue.

Dehydration Market

Data needed to build a similar model for the dehydration market were not available from public sources. We were unable to find Idaho-specific data so we built a simple US model. Compounding the lack of data problem was the fact that dehydrated potatoes are sold in multiple product types and multiple markets. Using ordinary least squares (OLS) we estimated an inverse demand function for all dehydrated potato products that included two explanatory variables. The dependent variable is:

P = average price paid by the US School Lunch program for dehydrated potatoes (\$/lb)

The explanatory variables are:

Q_{US} = Quantity of US potatoes dehydrated (million lb)

T = Year

We were able to obtain data only for 2000-2010. We expected a negative sign for the quantity coefficient but did not have a hypothesis about the time variable. We hoped that changes in market forces through time would be captured in the annual time variable. Like with the fresh potato demand model, we used the dehydration price flexibility to estimate impacts on dehydration processor revenue. Since we needed to convert US information to Idaho, we sought expert opinion regarding the share of US dehydrated potatoes produced in Idaho.

Results

Quantity

A graph of the average size distribution for the 2000 to 2010 crops shows that the largest category in the size distribution is '2" or 4-6 ounces' (Figure 1). This category comprises more

than one-fourth of the Eastern Idaho crop, at 26.8%. The values in this category ranged from a minimum of 21.9% in 2002 to a maximum of 32.7% in 2010. The category relevant to this research is the 4-6 ounce category. We assumed that one half of the 4-6 ounce range is made up of 4-5 ounce potatoes. This results in an average of 13.4% of the potato crop in the 4-5 ounce category.

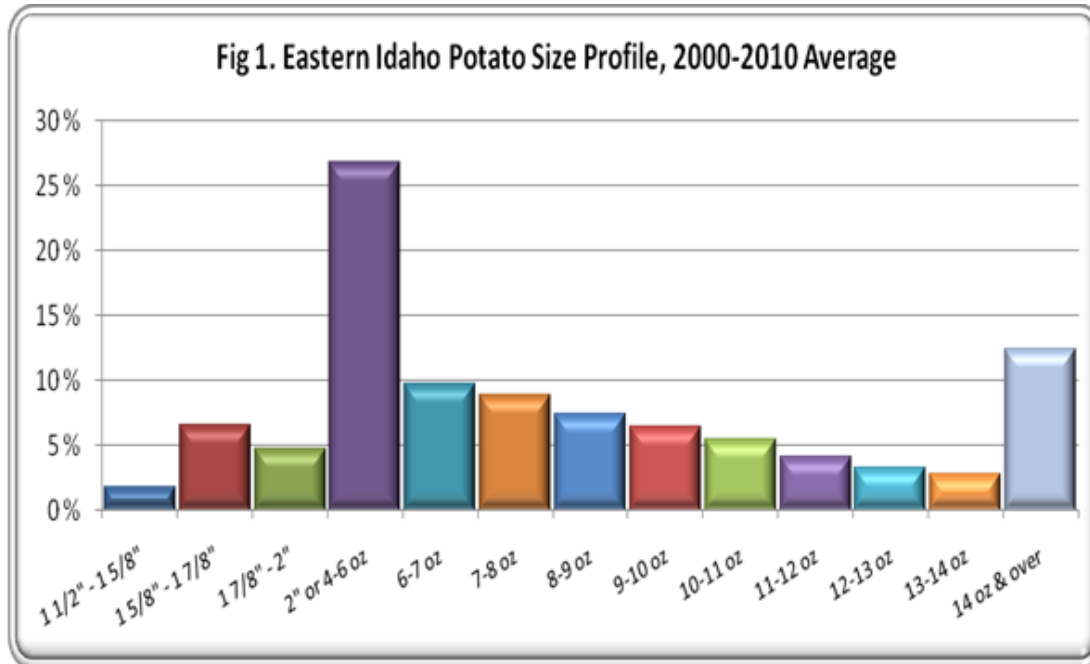


Figure 1. Eastern Idaho potato size profile

The three smallest categories (1 1/2" - 1 5/8"; 1 5/8" - 1 7/8"; 1 7/8" - 2") of potatoes would not typically make it to the fresh market. Excluding them from shipment quantities, provides an estimate that 15.4% of Idaho's fresh potato shipments have been in the 4-5 ounce category. According to the Federal-State Market News Service the 2000-2010 average for Idaho fresh shipments was 33.34 million cwt. That means that an average of 5.14 million cwt of 4-5 ounce potatoes would be diverted from fresh to dehydration if the minimum size were increased to 5 ounces. The average amount of Idaho fresh potatoes shipments would decrease from 33.34 million cwt. to 28.20 million cwt.

Fresh Market

Results for the monthly fresh model were disappointing (Table 1). We evaluated this model in terms of: (1) economic theory, (2) statistics and (3) econometrics and found serious shortcomings in all three. First, coefficient signs for two variables were contrary to economic theory. We expected a negative coefficient for US stocks because higher stocks would push down prices. The negative sign for the Quarter 3 dummy variable was also a problem. We hypothesized that increasing storage costs would put Q3 prices higher than harvest-time prices and give the variable a positive coefficient.

Table 1. Estimated coefficients and t-values for the monthly fresh potato model.

| Variable | Coefficient | T value |
|--|--------------------|----------------|
| Constant | 38.2 | |
| Q _{ID} (Idaho fresh potato shipments) | -0.43 | 3.25 |
| Q _{US} (non-Idaho fresh potato shipments) | -0.18 | 2.56 |
| S _{ID} (stocks of Idaho potatoes in storage) | -0.58 | 3.10 |
| S _{US} (stocks of non-Idaho US potatoes in storage) | 0.19 | 2.98 |
| I (disposable per capita personal income) | -0.15 | 0.81 |
| Adv (binary variable for national ads)* | 3.76 | 2.98 |
| Q1 (binary variable for quarter 1) | 1.58 | 1.26 |
| Q2 (binary variable for quarter 2) | 2.88 | 2.02 |
| Q3 (binary variable for quarter 3) | -0.94 | 0.79 |
| $R^2 = 0.33$ | | |

Another problem was the model's elasticity of -1.08, depicting an elastic fresh-potato demand, which contradicted previous research. One statistical concern was the insignificant t-value for the income variable. Another was the low R^2 value of 0.33, which indicated that the model only explained 33% of the variation in price. One econometric problem was multicollinearity because of a 98% correlation between the stocks variables. Based on these shortcomings we rejected the monthly model.

Price volatility within the market year may be one reason the monthly model was not a good fit. Since the consensus among other researchers is that fresh potato demand is inelastic, volatile prices are expected. Price volatility within the marketing year is likely exacerbated by uncertainty in the actual quantity of potatoes in storage, the possibility of excessive storage shrink due to diseased potato tubers, the size profile of potatoes yet to be shipped and the uncertainty about the supplies of fresh potatoes to be harvested during winter, spring and summer.

Table 2. Estimated coefficients and t-values for the annual fresh potato model.

| Variable | Coefficient | T value |
|--|--------------------|----------------|
| Constant | 40.23 | |
| Q _{ID} (Idaho fresh potato shipments) | -2.39 | 4.73 |
| Q _{US} (non-Idaho fresh potato shipments) | -29.22 | 3.37 |
| $R^2 = 0.73$ | | |

We thought that an annual model could more accurately depict the fresh potato price-quantity relationship because total production of Idaho and US potatoes may be the most significant variables that influence average prices. The coefficient signs for the explanatory variables were as hypothesized (Table 2). The negative signs on the variables indicate that the demand for Idaho fresh potatoes is normal and that non-Idaho potatoes are substitutes. According to the R^2 value,

the model explains 73% of the changes in annual Fresh Weighted Average (FWA) prices. The variables were statistically significant at the 5% level for type 1 error. Diagnostic tests revealed heteroskedasticity was not present, autocorrelation was inconclusive, and no problems existed for multicollinearity. In order to check for heteroskedasticity, the critical value for the χ^2 distribution is compared to the independent variables. At 1 degree of freedom and $\alpha=0.025$, the critical value is 5.024 (Griffiths, Hill, & Judge 1993). The critical value for the P-Values is 0.05. The test results for heteroskedasticity are:

Table 3. Test results for heteroskedasticity

| | Chi-Square | D.F. | P-Value |
|---------------------------------------|-----------------------|-------------|----------------|
| | <i>Test Statistic</i> | | |
| E^2 on \hat{Y} : | 0.042 | 1 | 0.83746 |
| E^2 on \hat{Y}^2 : | 0.087 | 1 | 0.76820 |
| E^2 on $\text{LOG}(\hat{Y}^2)$: | 0.018 | 1 | 0.89349 |
| E^2 on $\text{LAG}(E^2)$ Arch Test: | 0.342 | 1 | 0.55883 |
| $\text{LOG}(E^2)$ on X (Harvey) Test: | 4.013 | 2 | 0.13447 |
| $\text{ABS}(E)$ on X (Glejser) Test: | 0.977 | 2 | 0.61349 |
| E^2 on X Test: | | | |
| Koenker (R^2): | 0.120 | 2 | 0.94165 |
| B-P-G (SSR): | 0.075 | 2 | 0.96307 |
| E^2 on $X X^2$ (White) Test: | | | |
| Koenker (R^2): | 1.109 | 4 | 0.89286 |
| B-P-G (SSR) : | 0.694 | 4 | 0.95205 |

Comparing the Chi-Squared test statistics and the P-values to their respective critical values, it is concluded that heteroskedasticity is not present. The critical values for the Durbin –Watson Test at a 5% significance level are found where $k=2$ and $t=11$ (Griffiths, Hill, & Judge 1993). K is the number of dependent variable and t is the number of years in our regression. These values are: $d_{LC} = .927$ and $d_{UC} = 1.324$. Since the d value for this regression is between the critical values we do not reject $H_0: \rho=0$. This leads to the conclusion that autocorrelation likely does not exist.

The variables were regressed on each other, and the highest R^2 was 0.38, lower than the annual model R^2 . This suggests that no problems exist for multicollinearity.

The price flexibility (F) at mean values of the variables is -2.5. For each 1% change in the quantity of Idaho potatoes shipped, the FWA moves 2.5% in the opposite direction. The inverse of that number, which is an approximation of elasticity (Tomek and Robinson 1990), is -0.4 which puts Idaho fresh potato demand in the ‘inelastic’ category.

Table 4. Impact of 5-ounce minimum on Idaho potato shipper revenue.

| | Min = 4 oz | Min = 5 oz | Difference |
|------------------------|--------------------------|-------------------|-------------------|
| Quantity (million cwt) | 33.34 | 28.2 | -5.14 |
| Price (\$/cwt FWA) | \$12.84 | \$17.78 | \$4.94 |
| Revenue (\$ million) | \$428 | \$501 | \$73 |
| | <i>Average 2000-2010</i> | <i>Estimated</i> | |

For the 15.4% reduction in fresh Idaho potato shipments, we expect the price to increase 38%. The fresh weighted average price in Idaho for 2000-2010 was \$12.84. An increase by 38% will result in a FWA price of \$17.78 per cwt after diversion of the 4-5 ounce potatoes. The average revenue for Idaho fresh potatoes from 2000-2010 was \$428 million. Revenue after diversion of the 4-5 ounce potatoes would have been \$501 million, a difference of \$73 million (Table 3). Given that non-Idaho potatoes are substitutes for Idaho potatoes, it is reasonable to assume that the substitute effect will come into reason when consumers are at the market.

Dehydration Market

The two-explanatory-variable model explains 92% of the variation in prices for dehydrated potatoes (Table 5). The coefficient of +0.083 for the time variable indicates that there is an upward trend in prices of about \$0.08 per cwt each year. Although the model does not explain the economic forces that are pushing the price up, it shows that demand for dehydrated potatoes has been increasing. Both variables are statistically significant at the 90% level. Diagnostic tests revealed that autocorrelation likely does not exist, heteroskedasticity was inconclusive, and no problems existed for multicollinearity.

Table 5. Estimated coefficients and t-values for the dehydrated potato model.

| Variable | Coefficient | T value |
|-----------------------------------|-------------|---------|
| Constant | -164.5 | -5.8 |
| Q (US dehydrated potato quantity) | -0.001 | -1.5 |
| T (2000-2010) | 0.083 | 5.8 |
| $R^2 = 0.92$ | | |

F is -0.54 at the mean values of the variables. The inverse is -1.8, which indicates that the demand for dehydrated potatoes is in the 'elastic' category. Diverting 5.14 million cwt from the fresh market to the dehydrated market, at an 8:1 raw to finished product conversion rate (USDA ERS 1992), would increase the US dehydrated supply by 11.65%. This would cause finished product price to decline by 6.3% from \$0.99 to \$0.93 per pound. The 2000-2010 average dehydrator revenue was \$545 million. Revenue with the diversion would have been \$570 million, a \$25 million, or 4.6% increase (Table 6).

Table 6. Impact of 5-ounce minimum on Idaho potato dehydrator revenue.

| | Min = 4 oz | Min = 5 oz | Difference |
|----------------------------|--------------------------|------------------|-----------------|
| US Quantity (million lbs.) | 550.4 | 614.5 | 64.1 |
| US Price (\$/lb.) | \$0.99 | \$0.93 | (\$0.06) |
| US Revenue (\$ million) | \$545 | \$570 | \$25 |
| ID Revenue (\$ million) | \$381 | \$399 | \$18 |
| | <i>Average 2000-2010</i> | <i>Estimated</i> | |

We interviewed several anonymous industry experts about the share of US dehydrated potatoes that are produced in Idaho. We used an average estimate of 70%. Applying that percentage to the US figures, we estimated that the diversion would increase Idaho dehydrator revenue by \$18 million.

Sensitivity Analysis

The impact estimates are based on averages for the quantity of Idaho fresh potatoes shipped and the portion of potatoes in the 4-5 ounce range. We conducted a sensitivity analysis to estimate the impacts when those two variables were at their highest and lowest values from 2000 to 2010 (Table 7). We found that the largest impact would have been when Idaho fresh shipments were at the largest, which was 37.3 million cwt for the 2000 crop. With that quantity and a 5-ounce minimum, revenue would have increased \$132 million in the fresh industry and \$20 million in the dehydration industry. The next largest increase in revenue (\$105 million) would have been when the largest share of fresh potatoes were in the 4-5 ounce category, which was 19.7% in 2010. The biggest benefits occur when large quantities of potatoes are diverted from fresh to dehydration.

Table 7. Sensitivity analysis for Idaho potato industry revenue.

| | Fresh | Dehy | Total | Change |
|-----------------------------|--------------|-------------|--------------|---------------|
| Actual 2000-10 average | \$428 | \$381 | \$809 | - |
| Min = 5 oz | \$568 | \$399 | \$900 | \$92 |
| <i>ID Quantity shipped:</i> | | | | |
| Largest (37.3 mcwt) | \$561 | \$401 | \$961 | \$152 |
| Smallest (30.7 mcwt) | \$462 | \$398 | \$859 | \$50 |
| <i>Size profile:</i> | | | | |
| Highest 4-6 oz (19.7%) | \$518 | \$396 | \$914 | \$105 |
| Lowest 4-6 oz (12.3%) | \$489 | \$399 | \$888 | \$78 |

Note: Revenue is million \$

Conclusion

Through our final annual model, we have predicted that by shifting Idaho's 4 to 5 ounce supply of potatoes (5.14 million cwt) from the fresh to the dehydrated market, an increased revenue of nearly \$150 million can be expected.

The fresh potato market has flexibility of -3.5, resulting in a \$6.93 FWA increase per cwt. This results in an overall \$130 million increased revenue for the Idaho's fresh potato industry.

The dehydrated potato market has a flexibility of -0.5, resulting in a \$0.06 decrease per pound of dehydrated potatoes. The quantity being shifted from fresh to dehydrated markets is enough to offset this price decline, and result in a \$20 million increase for the dehydrated market.

Discussion

Diverting 4-5 ounce potatoes from the fresh market to the dehydrated market would affect multiple parts of the Idaho potato industry. Total revenue would increase in both market sectors and economic benefits would spill over into agricultural supply businesses, other parts of the potato industry and the overall Idaho economy. This research project provided some answers for the IPC question about the impacts of increasing the minimum size, but some unanswered questions and issues are discussed below.

Monthly Model

We intended to build a model for monthly fresh potato prices, but were not successful. One reason may be price volatility due to uncertainty about storage stocks and potatoes harvested in winter, spring and summer. Total potato supply may be a more reliable predictor of annual prices than monthly shipments are for monthly prices. If prices are unusually high or low early in the marketing season, price corrections later could bring the average price back to a level that is easier to predict.

Quality Impact

More uniform sizing could increase demand for Idaho fresh potatoes. During summer 2011 United Potato Growers of Idaho suggested price premiums of \$0.75 to \$1.50 per cwt for consumer packs with a five ounce minimum. (United Potato Growers of Idaho 2011). Since we did not include a price premium in our analysis, the impact estimates may be conservative.

Costs

Reducing fresh potato shipments could increase packing fixed costs per unit. Declines in volume would mean that some packers would spread the same amount of fixed costs over fewer units shipped. The dehydration industry might also face changes in costs due to changes in volume. Cost analysis was not part of this study.

Price Sensitivity

Previous research sponsored by IPC found a fresh potato price elasticity of -0.14 (Guenther 2001). This implies that a one percent change in supply causes a seven percent change in price. Our research found smaller price sensitivity, for which there are several reasons. First, the earlier study analyzed a different product— US fresh potatoes. Second, the earlier study was conducted at the retail level and this one was at the packer level. Third, the earlier study used data from 1975-1988 and market behavior may have changed since then.

Grower Impacts

The analysis was conducted at the fresh shipper and dehydration processor links of the marketing chain, but the results can be extended to growers. Impacts on Idaho fresh potato growers would include lower fresh pack-out rates, higher prices for fresh potatoes, lower prices for dehydrated-

quality potatoes, and a higher net price. Using the estimated price flexibilities, we estimated that the average GRI price of \$5.63 per cwt for the 2000-2010 crops would have been 24% higher at \$6.97 had the five-ounce minimum standard been in place.

Supply Response

Our analysis focused on short-run impacts only. A long-run analysis would include a model of how growers' plantings and production would respond to changing fresh potato prices. Guenthner (1987) estimated Eastern Idaho potato plantings elasticity at 0.25 but that was based on data from 1962-1985. The supply control programs of the United Potato Growers cooperatives have likely made acreage response more inelastic (Guenthner 2012).

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