THESIS

# AN ESTIMATED SYSTEM OF DEMAND FOR SPECIALTY POTATO VARIETIES: MARKETING IMPLICATIONS FROM A MULTI-CITY COMPARISON


Submitted by

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# ABSTRACT

## AN ESTIMATED SYSTEM OF DEMAND FOR SPECIALTY POTATO VARIETIES: MARKETING IMPLICATIONS FROM A MULTI-CITY COMPARISON

The decline in annual fresh potato consumption in the U.S. has been especially difficult for the Colorado potato industry since their product is primarily targeted for the fresh market. A more recent trend, which may provide opportunity for the Colorado potato industry, is reported growth in consumer interest in fresh specialty potatoes. Through an analysis of market level data, the objective of this research project is to inform the marketing efforts of the Colorado Potato Administrative Committee and individual potato growers in Colorado on the emerging specialty potato market opportunities that may exist. Deaton and Muellbauer's (1980) linear approximate almost ideal demand system is used to recover and compare price and expenditure elasticities for eight potato varieties across five U.S. cities. Results from this project indicate that significant differences exist in consumer behavior for specialty potato varieties relative to the well-established Russet potato. Specifically, the modeling techniques used in this paper find that consumers are often more sensitive to changes in the price of specialty potatoes relative to the well-established Russet potato.

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# CHAPTER 1: STATEMENT OF PROBLEM AND LITERATURE REVIEW

## 1.1 Introduction

The potato industry in the U.S. has witnessed a decline in annual per capita consumption of fresh potatoes since at least 1970, as shown by the red line in Figure 1.1 (USDA-ERS, 2011).

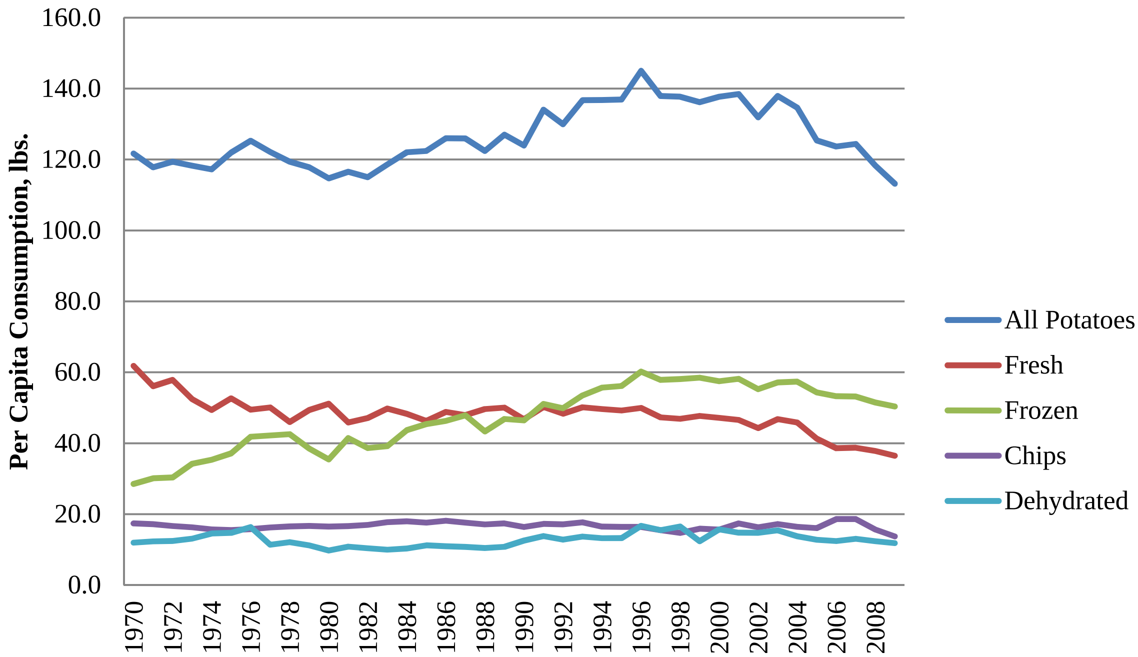


**Figure 1.1  U.S. Annual Per Capita Potato Consumption, 1970-2009**

During the past forty years, annual per capita consumption of fresh potatoes shrank by one-third from more than 60 lbs. in 1970 to less than 40 lbs. in 2009. Comparatively, annual processed potato consumption has experienced a significant amount of growth during this time, increasing from 69 lbs. per capita in 1970 to 83 lbs. in 2011 (USDA-ERS, 2011). The decline in annual fresh potato consumption can be largely attributed to the growth in frozen potatoes, which saw significant increases from the 1970s through the 1990s. Included as a reference, the purple and light blue lines in the figure represent potato chips and dehydrated potatoes, which experienced a lower per capita consumption throughout the time period relative to fresh and frozen potatoes.

A more recent development in the potato market is reported growth in consumer demand for fresh specialty potato varieties. In 2011, specialty potatoes were the fastest-growing segment of the potato category with a reported 73% increase in volume of bagged sales, and a 62% increase in dollar sales (USPB, 2011). Specialty potatoes are defined as a niche market for a premium product, which separates them from the well-established potato varieties, such as red, white, and Russet potatoes, that consumers may be more familiar with. Specialty potatoes tend to be unique cultivars of high quality, and are available in diverse colors, textures, and sizes (Olsen et al., 2003). Despite the level of recent growth, specialty potatoes accounted for less than 1% of total bagged pounds of fresh potatoes sold in 2011 (USPB, 2011).

Historically, the Colorado potato industry has primarily been characterized by the fresh potato market. In 2010, the Colorado potato industry ranked #5 nationally for fall potato yields among potato producing states (USDA-NASS, 2010), and had an estimated average 390 cwt. per acre (USDA-NASS, 2011a). Since Colorado growers primarily participate in the fresh potato market, the contraction in annual fresh potato consumption is especially difficult for Colorado potato growers. Thus, entry into the emerging specialty potato markets is an especially important opportunity for Colorado fresh potato growers. Although Colorado growers planted more than 100 different potato cultivars for the 2010 fall crop (USDA-NASS, 2010), the most commonly planted cultivars have historically been Russets, which collectively represent more than 85% of planted acreage in Colorado (USDA-NASS, 2011a; 2011b). Recently, the Colorado State University (CSU) potato breeding program has developed new specialty potato cultivars including the Purple Majesty, Lady Pinto, and Aspen Russet (Bond et al., 2011). These new varieties are thought to be especially appealing to both growers and consumers in light of improved production attributes and enhanced nutritional and sensory features. However, little marketing information exists for many of the Colorado specialty potatoes due to the newness of the product in the market. In order to support the adoption of these new varieties by both producers and consumers, the Colorado Potato Administrative Committee (CPAC) and faculty of CSU's San Luis Valley Research Center have obtained specialty crops grant funds. These funds have been used to support a multi-year investigation of the market potential and opportunities for the aforementioned Colorado specialty varieties, as well as the category of specialty potatoes more generally. This thesis is the product of the marketing investigation, the contents of which are intended to address the above issues and ultimately inform the marketing efforts of CPAC and individual potato growers in the state on emerging specialty potato market opportunities. In the first section of this thesis, an analysis of market data for specialty potato varieties is conducted and supplementary potato market data is synthesized. Systems of demand equations are used to investigate the heterogeneity of consumer demand for specialty potatoes between five major U.S. cities: Atlanta, Chicago, Dallas, Los Angeles, and New York. Although previous research has estimated consumer demand for potatoes at the varietal level, (Bond and Richards, 2008; Hsieh, Mitchell, and Stiegert, 2009), these studies have ignored the heterogeneity between different regions of the U.S. by estimating demand at the national level only. This study also evaluates how carbohydrate substitutes and major holidays impact consumption of specialty potatoes. The next section of this thesis features a comprehensive marketing plan for Colorado specialty potatoes, including both 4Ps and SWOT analyses. In the final section, a summary of research findings and future research extensions of this work is presented.

## 1.2 Literature

The literature related to this paper can be divided into two categories. The first category of studies primarily uses survey instruments to estimate consumer preference and willingness to pay for various potato attributes. The second category of studies uses market level data to estimate consumer demand for potatoes. The former body of literature is included in this paper to highlight existing knowledge of consumer preferences towards potato attributes, and to provide support in developing a marketing strategy presented later in this paper. The latter body of literature has studied the revealed consumer behavior in potato consumption by analyzing market-level sales data. These studies used systems of equations to estimate demand relationships between the potato category and other foods, as well as demand relationships between cultivars within the potato category. The model developed in this paper fits into the latter body of literature by estimating multiple systems of demand equations for eight potato cultivars.

### *1.2.1 Survey Studies*

A study from 2001 surveyed consumers in Colorado to estimate the willingness to pay for various potato attributes (Hine, Loureiro, and Meyer, 2001). Survey results found that appearance, flavor, size, nutrition, and price were the most important attributes when purchasing potatoes. The results from a more recent experimental and sensory analysis study on specialty potatoes found that consumer respondents cite taste, physical characteristics, and prices as the top three most influential factors in the potato purchase decision (Bond et al., 2011). Conversely, their results found that source (location of growth) was one of the least important attributes in potato purchasing decisions. In that same study, researchers found that all of the value-added specialty potato varieties used in the experiment had a higher average willingness to pay relative to the well-established Russet potatoes. They also found a slight increase in average willingness to pay upon revelation of the nutritional characteristics of the potato varieties. The specialty variety, Purple Majesty, experienced the greatest increase in the respondents' willingness to pay upon knowing the nutritional characteristics. Unlike the results from Hine, Loureiro, and Meyer (2001), Bond et al. (2011) found that nutrition was one of the least important potato attributes to consumers.  Hine, Loureiro, and Meyer (2001) found that variety type and organic certification where the least important attributes when purchasing potatoes. However, 48% of survey respondents from indicated that they would be willing to pay a premium for specialty potatoes, and 25% indicated that they would increase potato purchases if more fresh varieties were available. Their results also found that 61% of respondents would be willing to pay a premium for Colorado grown potatoes. A similar study by Loureiro and Hine (2002) found that the mean willingness to pay for locally grown Colorado potatoes was greater than for organic and GMO-free potatoes. Specifically, they found that the mean willingness to pay for Colorado-grown and organic potatoes was 5.5 cents per pound and 3.1 cents per pounds above the initial price of $1 per pound without such attributes.  Their results also indicated that a higher level of tuber quality must be met for consumers to pay such a premium for locally grown potatoes. Similar survey results from Cook et al. (2000) indicated that the majority of Delaware respondents preferred Delaware-grown potatoes. A more recent study by Jemison, Sexton, and Camire (2008) surveyed consumers in Maine, and found that the most important characteristics that influence fresh potato consumption were skin quality and place of origin. Their results also found that variety type was roughly as important as potato size, skin color, flesh color, and cleanliness; however, as an attribute, "novelty variety" (i.e. specialty potatoes) was found to be the least important of the available potato attributes compared in the survey. Results from Cheng, Peavey, and Kezis (2001) indicated regional differences in a potato attribute survey study. Product origin played a prominent role in potato purchasing decisions for respondents from Springfield, Massachusetts. For respondents from Hillsborough, North Carolina, price was the most important attribute in purchasing decisions.

In summary, these studies tended to find that physical attributes of potatoes were rated high in terms of importance to consumers, although there is some debate on the relative importance of nutritional quality. Routinely, prices were found to be among the highly important attributes, but were never rated as the most important attribute to consumers. These studies indicate that variety type and the availability of different varieties were only marginally important to consumers; however, there is evidence that consumers are willing to pay a premium for locally grown and specialty potato varieties. The literature in the following subsection used market level data to estimate consumer demand for potatoes. Several of these studies compared demand for potatoes as part of a broader food category (i.e., carbohydrates or vegetables), while others estimated systems of equations to assess consumer demand at the variety level.

#### *1.2.2 Consumer Demand Studies*

Richards, Kagan, and Gao (1997) studied how socioeconomic factors contributed to the decline in fresh potato consumption. In this study, fresh potatoes were assumed to be part of a carbohydrate food category that also included rice, pasta, and bread. Their results found that the socioeconomic characteristic variables explained only a small portion of the decline in demand, whereas a change in consumer tastes and preferences had a significantly larger impact on the change in demand for fresh potatoes. Their results also identified significant uncompensated complementary effects between potato consumption and the price of rice and pasta; no uncompensated price-effects were identified between potatoes and the price of bread. This study concluded that demand for fresh potatoes had increasingly become relatively price inelastic over time. A similar study by Gao, Richards, and Kagan (1997) developed a system of demand equations to explain how consumer tastes for carbohydrates may have impacted demand for the category as a whole. Similar to Richards, Kagan, and Gao (1997), their model considered potatoes as part of a broad category of complex carbohydrates (potatoes, bread, rich, pasta, and corn).

Yen et al. (2004) estimated a system of demand equations that included potatoes as part of the vegetable category of interest. Their approach differed from Gao, Richards, and Kagan (1997) and Richards, Kagan, and Gao (1997) due to the fact that they estimated potato demand relationships with respect to other vegetables as opposed to carbohydrate goods. Their approach also differed due to the fact that they estimated two systems of equations; one for high-income households, and one for low-income households. Yen et al. (2004) found that low-income households had elastic demand for potatoes with respect to price, while high income households had inelastic demand. A similar study by Zhang et al. (2006) used scanner data to examine national demand for organic and conventional vegetables, and included potatoes as part of the vegetable category. They found that organic potato prices were roughly 75% higher than conventional potato prices. Their estimated results showed that potatoes were the only organic vegetable evaluated that had an elastic own-price effect.  Potatoes were also found to be the only vegetable with a significant substitution relationship between the organic and conventional product methods.

Bond and Richards (2008) used a system of equations approach to estimate the impacts of generic promotion on consumer demand for non-Russet potatoes. This study used a two-stage modeling approach that first, accounted for the impacts of the price of carbohydrate substitutes on the potato category, and second, estimated pricing relationships between potato varieties within the potato category. This study found that demand for Russets, reds, and whites were price inelastic, while specialty potatoes such as the Yukon, yellow, and organic varieties were found to be price elastic. Their model found highly significant holiday effects on potato consumption; the weeks prior to a major American holiday experienced significant increases in consumption, while the week following had decreases in consumption. Unlike Richards, Kagan, and Gao (1997), Bond and Richards failed to find significant price effects of other carbohydrate foods on potato consumption. This paper also indicated that regional differences in potato consumption exist, and should be taken into account when developing promotional programs.

A similar study by Hsieh, Mitchell, and Stiegert (2009) estimated the impacts of emerging demand for organic foods on fresh potato consumption. They found that the "minor-colored" specialty potatoes and organic potatoes were most significantly impacted by increased penetration of organic food consumption, while white and russet potatoes appeared to be least effected. This study found little evidence of regional differences as evident by the lack of statistical significance of regional explanatory variables in the model. Their results suggested that the potato market was not very different across four distinct regions of the U.S.: east, central, south, and west. However, their study did find statistical significance of three regional explanatory variables included in one equation within the system: minor colored potatoes. Like Richards, Kagan, and Gao (1997) but unlike Bond and Richards (2008), this study found significant complementary relationships between the price of carbohydrate substitutes and well-established potato varieties. The study concluded that specialty and organic potatoes may be well positioned for the emerging demand for organic foods, while red, white, and russets have shown signs of slippage in the market.

A commonality between these studies is the estimation of a system of equations to better understand consumer demand for potatoes. Gao, Richards, and Kagan (1997), Richards, Kagan, and Gao (1997), and Zhang et al. (2006) estimated a system of demand equations using Deaton and Muellbauer's almost ideal demand system (AIDS model) (1980a). Yen et al. (2004) also used a systems approach, but used a translog demand system as opposed to the AIDS model. These studies only estimated consumption of potatoes at the category level, whereas Hsieh, Mitchell, and Stiegert (2009) and Bond and Richards (2008) estimated consumer demand at the varietal level. Hsieh, Mitchell, and Stiegert (2009) and Bond and Richards (2008) each used an adaptation of Deaton and Muellbauer's AIDS model. Generally, these studies found conflicting results on the price-effects of other carbohydrate goods on consumption of potatoes. Bond and Richards (2008) found no effect, while Hsieh, Mitchell, and Stiegert (2009) found that the Russet, white, and red varieties had complementary relationships with the price of rice and pasta.

Although Hsieh, Mitchell, and Stiegert (2009) found regional differences in "minor colored" potatoes, and Bond and Richards (2008) found significant regional differences in consumption patterns, the modeling techniques used in these papers may be missing an important component of demand analysis. What is lacking in this body of literature is a more clear understanding of the nature of heterogeneity between regions, and cities with respect to consumer demand for potatoes. The current state of literature using the system of equations approach to model consumer demand for potatoes has relied on the use of regional dummy variables to explain such differences. However, the use of such dummy variables cannot predict price and expenditure elasticities; they only estimate differences in expenditure share by variety per city. By aggregating regional sales data to fit a system of demand equations on a national level, and then using regional dummy variables to explain differences in consumption fails to capture important information; namely region specific price and expenditure elasticities.

A better approach is to separate the data by cross-section and estimate a system of demand equations for each region or, in the case of this study, cities. It is expected that the city specific consumer demand for specialty potatoes differ due to the assumed cultural, demographic, and economic heterogeneity between the cities. The main contribution of this study is to compare the estimated price and expenditure elasticities for the various potato cultivars between these five cities.

# CHAPTER 2: METHODOLOGICAL APPROACH AND DATA

In the current investigation, Deaton and Muellbauer's (1980) almost ideal demand system (AIDS) is used to estimated consumer demand for eight potato varieties in five U.S. cities. This econometric model is appealing because it gives an arbitrary first-order approximation to any demand system, satisfies axioms of choice exactly, and it aggregates perfectly over consumers without invoking parallel linear Engel curves (Deaton and Muellbauer, 1980). This model was also chosen due to the relative ease of estimation as nonlinear techniques are not required. The system of demand equations developed by Deaton and Muellbauer (1980) is first presented generally, and is then followed by an explanation of the appropriate formulas to calculate the own-price, cross-price, and expenditure elasticities. Next, the data used in this study is described along with the justification for inclusion of select variables in the model. Finally at the end of this chapter, the empirical demand system is presented and accompanied with a discussion of specific variables of interest to this study.

## 2.1 The Almost Ideal Demand System

Equation (1) shows the expenditure share equation. Each good within the system is characterized by an expenditure share equation for *n* number of goods represented as $i$ = 1 to *n* at time *t*.

$$w_{it} = \alpha_i + \sum_j \gamma_{ij} ln(P_{jt}) + \beta_i \, ln\left(\frac{X_t}{P_t}\right) \tag{1}$$

The dependent variable is the expenditure share for the $i^{th}$ good, and is defined as:

$$w_{it} = \frac{P_{it} \cdot Q_{it}}{X_t}$$

where:

$$P_{it} = \text{price}$$

$$Q_{it} = quantity$$

$$X_t = \sum_i P_{it} Q_{it} = total\ expenditure$$

The term $\alpha_i$ is constant, while the variable $\ln(P_j)$ denotes the price of each good within the system. The variable $ln\left(\frac{X_t}{P_t}\right)$ includes the total expenditures on the category, $ln(X_t,)$, and the price index, $ln(P_t)$. The price index, $ln(P_t)$, can be defined in several different ways. The almost ideal demand system includes the trans-log price index (2), but Deaton and Muellbauer (1980) recommend the use of the linearized version, namely Stone's price index (3).

$$lnP_t = a_0 + \sum_j \alpha_j lnP_j + \frac{1}{2}\sum_i^n \sum_j^n \gamma_{it} lnP_{it} lnP_{jt} \tag{2}$$

$$ln\,\bar{P}_t = \sum_i w_{it} \ln(P_{it}). \tag{3}$$

Equation (2) produces a theoretically correct price index per Deaton and Muellbauer (1980), and generates a nonlinear almost ideal demand system. The use of the Stone's price index (3) results in linearizing the system and produces an approximate of the trans-log price index (2). Deaton and Muellbauer (1980) aptly named the linear version to the AIDS model the linear approximate almost ideal demand system (LA/AIDS model).

This study uses the linear approximate almost ideal demand system due to the relative ease of estimation, and the comparability of estimates to the non-linear almost ideal demand system. Several studies have discussed the relationship between the linear and non-linear model specifications; some of these studies have shown through the use of Monte Carlo simulation that the linear model estimates compares well to the non-linear alternative (see: Altson, Foster, and Green 1994; Buse, 1994; Green and Alston, 1990; 1991; Hahn, 1994; Moschini, 1995; Moschini, Moro, and Green, 1994; Pashardes, 1993). However, one issue with the use of Stone's price index as a substitute for the trans-log price index is it generates simultaneity due to the expenditure share ($w_{it}$) appearing on both the right and left hand side of each expenditure share equation (Eales and Unnevehr, 1988). To correct for this, Eales and Unnevehr (1988) suggested substituting lagged one period budget shares into the Stone price index (4).

$$\ln \bar{P}_t = \sum_i w_{it-1} \ln( P_{it}). \tag{4}$$

From the model specification (1), the adding up conditions are automatically satisfied (5), while the homogeneity and symmetry conditions can be tested an applied in equation (6).

$$\sum_i \alpha_i = 1 \qquad \sum_i \beta_i = 0 \qquad \sum_i \gamma_{ij} = 0 \tag{5}$$

$$\sum_j \gamma_{ij} = 0 \qquad \gamma_{ij} = \gamma_{ji} \tag{6}$$

Provided the conditions in (5) and (6) hold, equation (1) will represent a system of demand equations, where the expenditure shares will sum to one as shown in equation (7).

$$\sum_i w_i \equiv 1 \qquad (7)$$

With these conditions met, the estimated coefficients in the system show the changes in real prices and real expenditure affect the expenditure share as the dependent variable. The $\gamma_{ij}$ coefficients show the estimated effects of real changes in price on the expenditure share. Specifically, each $\gamma_{ij}$ indicates an estimated 100 times effect on the expenditure share due to a 1 percent change in the $j^{th}$ price, conditional on no changes in real expenditure. The $\beta_i$ estimated coefficients show the effects from changes in real expenditure, $X_t$.

2.2 Calculating Elasticities

Price and expenditure elasticities are calculated using the parameter estimates from the linear approximate almost ideal demand. Following the recommendations of Green and Alston (1990), the uncompensated price elasticities are calculated using equation (9). This equation is used to calculate both own-price and cross-price elasticities.

$$\eta_{ij} = -\delta_{ij} + \frac{\gamma_{ij} - \beta_i \bar{w}_j}{\bar{w}_i} \qquad (9)$$

In equation (9), $\gamma_{ij}$ is the $i^{th}$ equation's estimated coefficient from the price of the $j^{th}$ good. $\beta_i$ is the $i^{th}$ equation's estimated coefficient on expenditure. The terms $\bar{w}_j$ and $\bar{w}_i$ are the mean expenditure shares for the $j^{th}$ good and the $i^{th}$ good, respectively. The term $\delta_{ij}$ is the Kronecker delta (10). When calculating a good's own-price elasticity the Kronecker delta equals 1, but equals zero when calculating a cross-price elasticity.

$$\delta_{ij} = \begin{cases} 1, & if\ i = j \\ 0, & if\ i \neq j \end{cases} \tag{10}$$

The expenditure elasticities are also calculated from the parameter estimates of linear approximate almost ideal demand system. For the $i^{th}$ good, the expenditure elasticity is calculated using equation (11).

$$E_i = 1 + \frac{\beta_i}{\bar{w}_i} \tag{11}$$

The $\bar{w}_i$ term is the mean expenditure share for the $i^{th}$ good, and $\beta_i$ is the $i^{th}$ equation's estimated coefficient on expenditure.

### 2.3 Data Description

Weekly potato sales data, provided courtesy of the United States Potato Board, was collected in five major U.S. cities: Atlanta, Chicago, Dallas, Los Angeles, and New York. Although referenced to as cities in this paper, the sales data were collected from the Metropolitan Statistical Area (MSA) of the referenced city from grocery stores with more than $2 million in annual sales. The dataset has 143 weekly observations, beginning with the week of January 8, 2006, and ending on September 28, 2008. Each observation has the total weekly pounds sold by potato variety along with the average price paid. For example, the first observation labeled as January 8, 2006 reports the total pounds sold and average price paid for each variety during the week beginning on the previous Monday. Total potato quantities sold were reported in pounds, while prices were reported in dollars per pound.

#### *2.4.1 Potato Varieties Included in the System of Demand Equations*

The data set used in this study includes sales information on many different potato varieties; well-established varieties, organically-grown, and specialty varieties were reported as being sold during this time. Originally, the data set included eleven varieties, each with organic and conventionally-grown versions. Other consumer demand studies treat organic and conventionally-grown products as different categories (Bond and Richards, 2008; Chang et al. 2011; Greenway et al., 2011; Hsieh, Mitchell, and Stiegert, 2009; Zhang et al. 2006). Twenty-two potato varieties are included in the data set; however, due to incomplete data on all potato varieties, several categories were either dropped or aggregated prior to estimation. To aggregate two or more potato varieties for each weekly observation, the pounds purchased were summed while a weighted average of prices of the aggregated varieties was calculated. After aggregating and dropping select potato varieties, the following eight potato varieties were included in system of demand equations: yellow, white, Russet, fingerlings, red, Idaho, creamers, and organics.

The purple potato variety was dropped due to lack of observations across the five cities. The variety labeled as “other” in the reported data was also dropped due to ambiguity of what consumers were buying. Other varieties were aggregated instead of being dropped due to characteristic similarities. The long-white variety was aggregated with the white variety due to physical similarities. Furthermore, since the long-white variety had a relatively high number of weekly pounds sold for some observations, aggregating the white and long-white varieties then mitigates some of the risk of specification bias that may resulted from dropping the long-white variety entirely. Red creamers and white creamers were also aggregated into one "creamer" category. Aggregating the red and white creamers into one variety was appropriate due to the differences in physical characteristics compared to the more mature red and white varieties. The main distinction of creamer varieties is that they are harvested at a much earlier stage of growth relative the longer grown red and white varieties; this results in creamers having smaller, more tender tubers with less flesh starch content relative to the more mature red and white varieties (Tecstra Systems, 2012).

Idaho potatoes are not necessarily a variety unto itself, but are instead a federally registered Certification Mark (Idaho Potato Commission, 2012). Any potato variety grown in Idaho is technically an Idaho potato. While Russets are the most commonly grown variety, more than twenty-five other varieties are currently grown in Idaho. One concern with the inclusion of Idaho potatoes as a separate variety was due to the lack of information of which specific potato varieties were being labeled as such; this was a similar issue surrounding the potato variety labeled as "other" in the dataset. However, the distinction between Idaho potatoes and the "other" variety, which was ultimately dropped, was that the former had significantly larger volumes of sales relative to the latter. Dropping Idaho potatoes from the system of demand equations would likely increase the risk of specification bias.  Additionally, it is reasonable to assume that fresh Idaho potatoes consisted mostly of Russets, because non-Russet varieties accounted for less than 10 percent of acreage planted in Idaho in both 2010 and 2011 (USDA-

NASS, 2011c). Therefore, Idaho potatoes were included as one distinct variety in the estimated system of demand equations.

Previous studies have found important substitution relationships between conventionally-grown potatoes and organic potatoes (Yen et al., 2004). It has also been found that “minor-colored” (i.e. aggregated specialty potatoes) and organic potatoes benefit the most from increased penetration of organic foods relative to total food sales in the U.S. (Hsieh, Mitchell, and Stiegert, 2009). However, lack of observations, inconsistent periods of sales, and small volume of sales relative to conventionally-grown potato varieties were issues for many of the organic varieties in the dataset. To reduce the specification bias in the model, the eleven organic potatoes varieties were aggregated into one “organic” variety. A more in depth discussion on organic potato trends can be found in Appendix A.

### *2.4.3 Considerations for Carbohydrate Substitutes*

Following the examples of previous potato demand studies, this paper will include the price of rice and pasta as an explanatory variable in each expenditure share equation. Average national prices of rice and pasta were extracted from the Bureau of Labor Statistics’ Average Price Data (BLS, 2012). However, as will be mentioned in section 2.5, this study assumes that the potato category is weakly separable from all other goods, which allows for estimation of the last stage of a multi-stage budgeting process (Edgerton, 1997). However, by estimating a demand system with the prices of carbohydrate substitutes (or complements) included as explanatory variables, but without an expenditure share equation for each of these goods, leads to a violation of the weakly separability assumption on a theoretical level. Empirically, the inclusion of the prices complements and substitutes as explanatory variables will fail to produce cross-price elasticities with respect to the goods found in the substitution matrix. What can be recovered from the inclusion of such explanatory variables is the relationship between the price of other goods and the expenditure share dependent variable.

## 2.4 Summary Statistics

Tables 2.1, 2.2, and 2.3 show the mean weekly pounds purchased, the mean weekly *per capita* pounds purchased, and the mean prices of the eight potato varieties by city, respectively. The mean values in each table were calculated over entire the sampling period, and are shown with standard deviation below in parenthesis.  Note that Table 2.1 describes the weekly pounds purchased which are used in the econometric estimation procedure, while Table 2.2 shows normalized weekly consumption by accounting for population size. Mean weekly per capita pounds purchased shown in Table 2.2 was calculated using population data from the U.S. Census (U.S. Census Bureau, Population Division, 2010). The last two columns of table 2.3 also show the mean price of pasta and rice, respectively.

Table 2.1: Mean Weekly Quantities (lbs.) by City During Data Collection Period

| | yellow | white | Russet | fingerling | red | Idaho | creamer | organic |
|---|---|---|---|---|---|---|---|---|
| Atlanta | 51,542 | 55,704 | 260,061 | 505 | 96,623 | 233,680 | 34,723 | 10,497 |
| | (19331) | (37176) | (88156) | (361) | (30502) | (78376) | (8259) | (27410) |
| Chicago | 101,989 | 112,597 | 526,519 | 1,034 | 223,364 | 142,955 | 32,085 | 17,909 |
| | (45140) | (26028) | (182492) | (417) | (87280) | (71102) | (28001) | (8660) |
| Dallas | 44,672 | 37,887 | 580,753 | 1,934 | 98,453 | 162,099 | 17,715 | 3,525 |
| | (21574) | (4808) | (120625) | (1545) | (20700) | (38555) | (3131) | (2792) |
| Los Angeles | 68,670 | 122,812 | 1,751,880 | 2,022 | 287,745 | 471,288 | 34,579 | 12,716 |
| | (24969) | (21962) | (349713) | (684) | (62157) | (258509) | (5767) | (5798) |
| New York | 227,664 | 488,220 | 1,057,805 | 1,543 | 413,380 | 412,187 | 87,688 | 37,440 |
| | (91548) | (294782) | (265966) | (796) | (142478) | (109271) | (19135) | (10357) |

Table 2.2: Mean Weekly Per Capita Quantities (lbs.) by City During Data Collection Period

| | yellow | white | Russet | fingerling | red | Idaho | creamer | organic |
|---|---|---|---|---|---|---|---|---|
| Atlanta | 0.010 | 0.011 | 0.050 | 0.00010 | 0.018 | 0.045 | 0.007 | 0.002 |
| | (0.004) | (0.007) | (0.017) | (0.00007) | (0.006) | (0.015) | (0.002) | (0.005) |
| | A | B | | | | | | E |
| Chicago | 0.011 | 0.012 | 0.056 | 0.00011 | 0.024 | 0.015 | 0.003 | 0.002 |
| | (0.005) | (0.003) | (0.019) | (0.00004) | (0.009) | (0.008) | (0.003) | (0.001) |
| | A | | C | | D | | | E |
| Dallas | 0.007 | 0.006 | 0.095 | 0.00031 | 0.016 | 0.026 | 0.003 | 0.001 |
| | (0.004) | (0.001) | (0.020) | (0.00025) | (0.003) | (0.006) | (0.000) | (0.000) |
| Los Angeles | 0.005 | 0.010 | 0.138 | 0.00016 | 0.023 | 0.037 | 0.003 | 0.001 |
| | (0.002) | (0.002) | (0.028) | (0.00005) | (0.005) | (0.021) | (0.000) | (0.000) |
| | | B | | | D | | | |
| New York | 0.012 | 0.026 | 0.056 | 0.00008 | 0.022 | 0.022 | 0.005 | 0.002 |
| | (0.005) | (0.016) | (0.014) | (0.00004) | (0.008) | (0.006) | (0.001) | (0.001) |
| | | | C | | D | | | E |

Letters A, B, C, D, and E indicate a failure to reject pair wise statistical difference at the 5% level of signficance between cities by variety

Table 2.3: Mean Weekly Prices ($) by City During Data Collection Period

| | yellow | white | Russet | fingerling | red | Idaho | creamer | organic | pasta | rice |
|---|---|---|---|---|---|---|---|---|---|---|
| Atlanta | 0.990 | 0.690 | 0.690 | 3.100 | 0.760 | 0.710 | 1.170 | 1.050 | 0.933 | 0.591 |
| | (0.164) | (0.104) | (0.158) | (0.727) | (0.117) | (0.124) | (0.126) | (0.303) | (0.110) | (0.089) |
| | | | | | | C | | E | | |
| Chicago | 0.920 | 0.800 | 0.510 | 2.780 | 0.670 | 0.470 | 1.610 | 0.650 | 0.933 | 0.591 |
| | (0.159) | (0.133) | (0.099) | (0.288) | (0.082) | (0.056) | (0.309) | (0.142) | (0.110) | (0.089) |
| | | | | | | D | | | | |
| Dallas | 0.780 | 0.950 | 0.540 | 1.750 | 0.830 | 0.690 | 1.680 | 1.040 | 0.933 | 0.591 |
| | (0.124) | (0.161) | (0.108) | (0.504) | (0.090) | (0.098) | (0.159) | (0.180) | (0.110) | (0.089) |
| | | | A | | B | C | | E | | |
| Los Angeles | 1.160 | 0.890 | 0.540 | 2.890 | 0.830 | 0.480 | 1.960 | 1.030 | 0.933 | 0.591 |
| | (0.151) | (0.120) | (0.054) | (0.125) | (0.081) | (0.085) | (0.085) | (0.145) | (0.110) | (0.089) |
| | | | A | | B | D | | E | | |
| New York | 1.020 | 0.560 | 0.730 | 3.250 | 0.960 | 0.800 | 1.870 | 1.130 | 0.933 | 0.591 |
| | (0.151) | (0.140) | (0.123) | (0.354) | (0.098) | (0.077) | (0.119) | (0.117) | (0.110) | (0.089) |

Letters A, B, C, D, and E indicate a failure to reject statistical difference at the 5% level of signficance between cities by variety

Tables 2.2 and 2.3 include the results from a means-comparison test. This test compared the mean prices and means per capita pounds of a given potato variety between the five cities in the dataset. The means-comparison test used a pair wise t-test that assumed unequal variances. Under the null hypothesis, the respective means (price or pounds) for a given potato variety are equal between two cities. Rows within a column with a matching bold capital letter indicate that the mean quantity or price between the respective cites were not found to be statistically different at the 5% level of significance. Rows in a column without a bold capital letter indicates that the means were found to be statistical different at the 5% level. For example, none of the rows within the forth column of table 2.2 (fingerlings) have capital letters below the standard deviation. This indicates the rejection of the null hypothesis of equal mean pounds purchased of fingerling potatoes between the five cities at the 5% level of significance. Alternatively, the first column of table 2.2 shows that the null hypothesis of equal mean pounds purchased of yellow potatoes between Atlanta and Chicago cannot be rejected at the 5% level of significance. In this case, the rows containing the mean per capita pounds purchased for Atlanta and Chicago contain "A" to signify that they were not found to be statistically different using this test.

The results of the means-comparison test show there to be a high frequency of rejecting the null that the means are equal. Shown in table 2.2, of the eighty means-comparison tests conducted to compare the mean weekly per capita pounds purchased, nine failed to reject the null at the 5% level of significance. Similarly, of the eighty tests conducted to compare the mean weekly prices shown in Table 2.3, seven failed to reject the null at the 5% level of significance. The high rejection rate of the null hypothesis of this test provides evidence of significant differences in the consumption of potatoes between the five cities.

A similar means-comparison test was conducted on the mean expenditure shares of each variety between cities, and is presented in table 2.4. Table 2.4 presents the mean expenditure share by variety per city along with the standard deviation below in parentheses.  This test provides further evidence that significant differences in potato consumption exist between the five cities.

Table 2.3: Mean Expenditure Share by City During Data Collection Period

| | yellow | white | Russet | fingerling | red | Idaho | creamer | organic |
|---|---|---|---|---|---|---|---|---|
| Atlanta | 0.090 | 0.067 | 0.323 | 0.003 | 0.132 | 0.298 | 0.074 | 0.012 |
| | (0.020) | (0.041) | (0.081) | (0.002) | (0.022) | (0.072) | (0.012) | (0.019) |
| | | A | | | B | | C | |
| Chicago | 0.123 | 0.127 | 0.367 | 0.004 | 0.204 | 0.095 | 0.064 | 0.016 |
| | (0.024) | (0.031) | (0.055) | (0.001) | (0.042) | (0.044) | (0.029) | (0.006) |
| Dallas | 0.055 | 0.059 | 0.509 | 0.005 | 0.135 | 0.183 | 0.050 | 0.006 |
| | (0.016) | (0.008) | (0.045) | (0.003) | (0.016) | (0.038) | (0.008) | (0.003) |
| | | | | | B | | | |
| Los Angeles | 0.047 | 0.066 | 0.568 | 0.004 | 0.143 | 0.125 | 0.041 | 0.008 |
| | (0.010) | (0.009) | (0.047) | (0.001) | (0.014) | (0.045) | (0.005) | (0.002) |
| | | A | | | | | | |
| New York | 0.104 | 0.111 | 0.351 | 0.002 | 0.183 | 0.153 | 0.076 | 0.019 |
| | (0.015) | (0.031) | (0.034) | (0.001) | (0.041) | (0.029) | (0.011) | (0.004) |
| | | | | | | | C | |

Letters A, B, and C indicate a failure to reject statistical difference at the 5% level of signficance between cities by variety

Similar to Tables 2.2 and 2.3, the matching bold capital letters within the same column indicate a failure to reject the null hypothesis of equal means. Relative to the previous two tables that compared the means of prices and quantities, the means-comparison test presented in table 2.3 had less instances of failure to reject the null. Presented in Table 2.3, the test results indicate that three of the eighty tests failed to reject the null hypothesis of equal means. Specifically, the expenditure share for white potatoes was not found to be statistically different between Atlanta and Los Angeles at the 5% level of significance. Similarly, the expenditure share for red potatoes in Atlanta and Dallas and creamer potatoes in Atlanta and New York were not found to be statistically different at the 5% level of significance, respectively.

The summary statistics and the means-comparison test found in tables 2.1, 2.2, 2.3, and 2.4 provide evidence that significant differences exist in potato consumption between the five cities in this study. However, what these tables do not provide is any indication of how the prices and quantity of pounds purchased may have changed over time nor the relationship of potato sales to various control variables. As such, a complementary econometric investigation which clarifies the significance and direction of variable relationships is described in Chapter 3. The quantity of pounds purchased by potato variety is shown graphically over time in figures 2.4 through 2.11. Each figure shows the quantity of pounds reported as being purchased for each weekly observation for the duration of the data collection period. The x-axis for all figures is in millions of pounds, except for fingerlings which are in thousands of pounds due to the relatively small volume of pounds purchased per week.

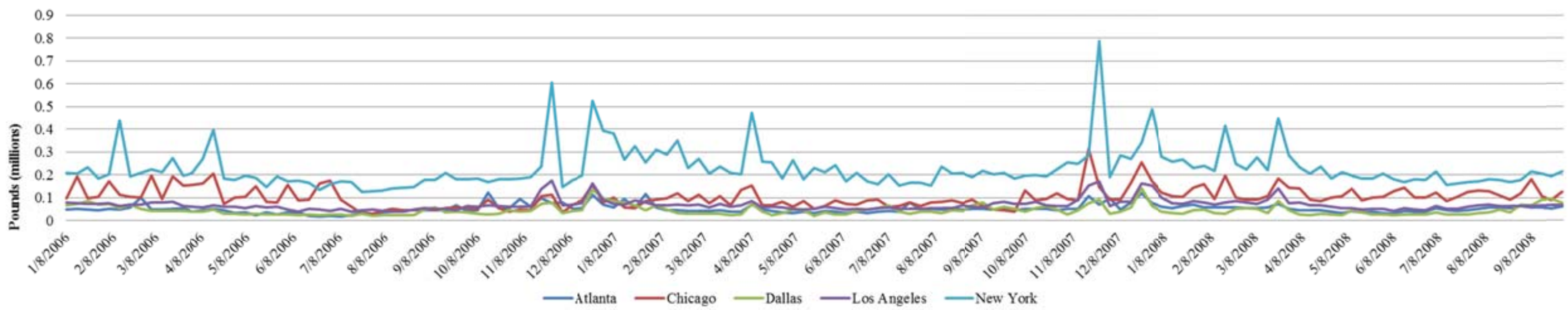


**Figure2.4: Weekly Yellow Potato Pounds Purchased from January 8, 2006 to September 28, 2008**

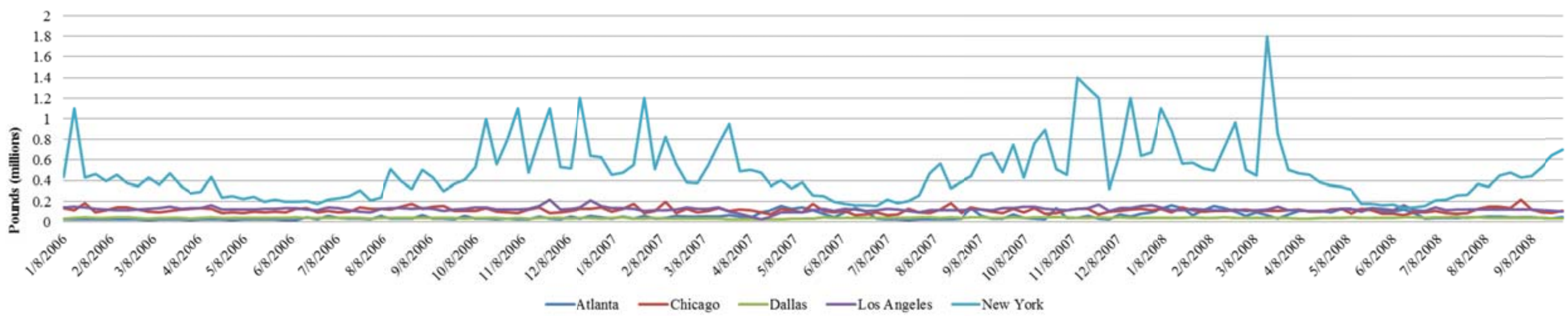


**Figure 2.5: Weekly White Potato Pounds Purchased from January 8, 2006 to September 28, 2008**

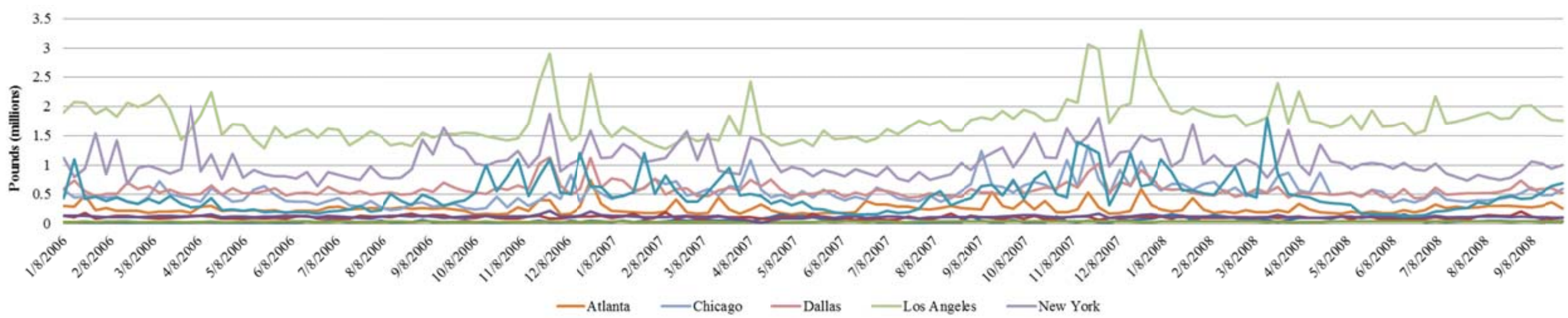


**Figure 2.6: Weekly Russet Potato Pounds Purchased from January 8, 2006 to September 28, 2008**

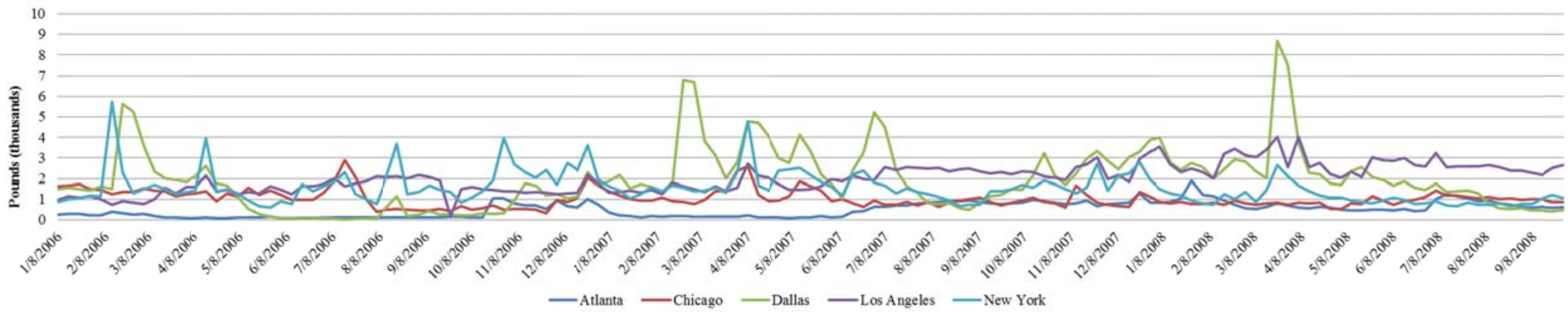


**Figure 2.7: Weekly Fingerling Potato Pounds Purchased from January 8, 2006 to Septemeber 28, 2008**

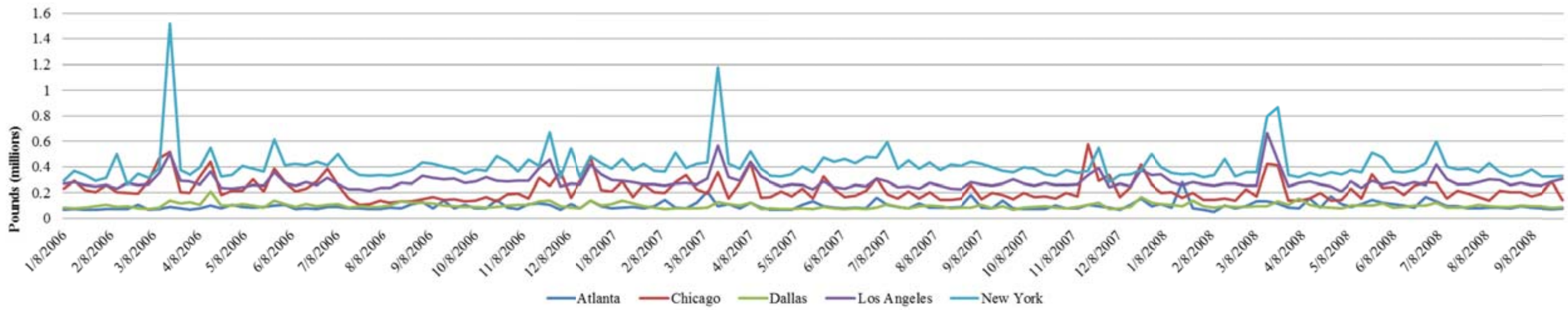


**Figure 2.8: Weekly Red Pounds Purchased from January 8, 2006 to September 28, 2008**

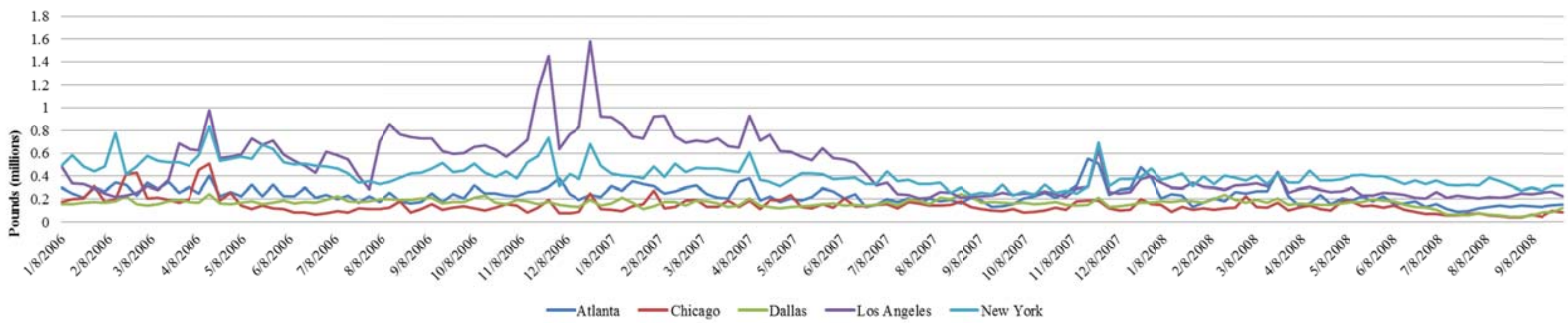


**Figure 2.9:. Weekly Idaho Potato Pounds Purchased from January 8, 2006 to September 28, 2008**

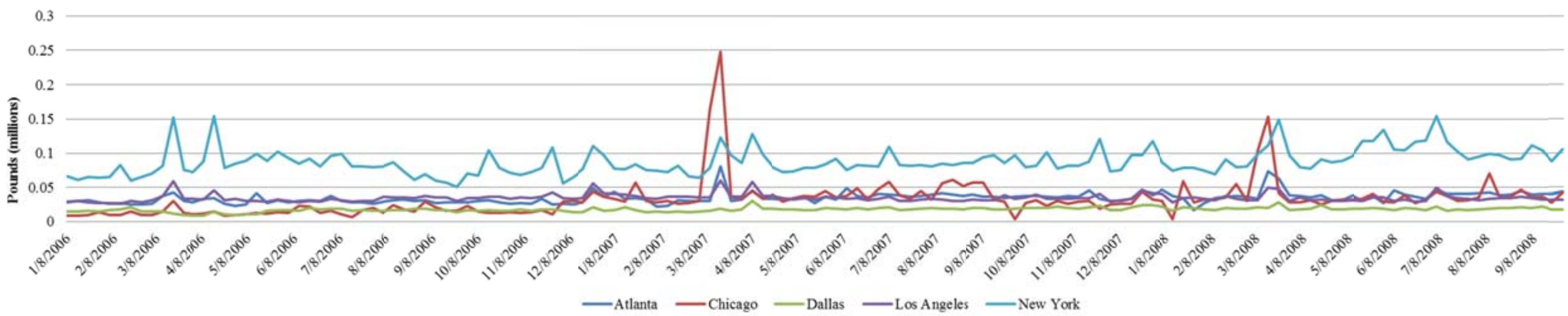


**Figure 2.10: Weekly Creamer Potato Pounds Purchased from January 8, 2006 to September 28, 2008**

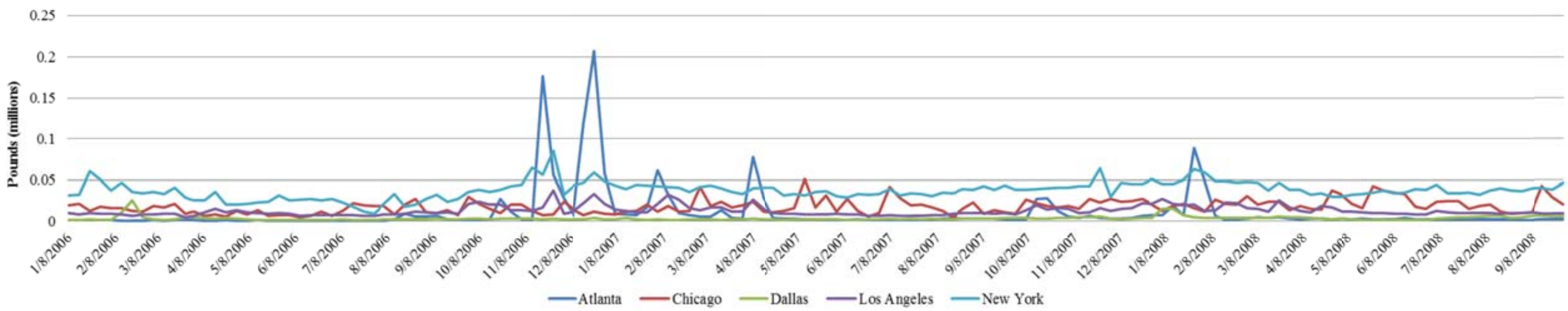


**Figure 2.11: Weekly Organic Potato Pounds Purchased form January 8, 2006 to September 28, 2008**

Figures 2.4 through 2.11 shows how the quantity of pounds purchased by variety differed between the five cities over time. Each figure will be discussed in order of presentation except for Figure 2.9, which will be discussed last. Figures 2.4, 2.5, and 2.6 clearly show a seasonal pattern in consumption during the winter months for yellow, white and Russet potatoes, respectively. New York consistently had the largest number of yellow and white potato pounds purchased weekly throughout the data collection period; Los Angeles generally had the greatest number of Russet pounds purchased weekly. Seasonal patterns in consumption for fingerling potatoes are difficult to determine by observing Figure 2.7. However, there may be some indication of seasonality in consumer behavior in purchasing fingerlings, as indicated by the slight increase in pounds purchased during November and December of 2008. There also is no clear indication of which of the five cities tended to purchase more fingerling potatoes on a weekly basis simply observing this figure. However, the means-comparison test found no statistical difference in the weakly pounds purchased between Dallas and Los Angeles; each average roughly 2,000 pounds of fingerling potatoes per week.

Figure 2.8 shows a slightly different pattern in a consumption of red potatoes over time compared yellow, white, and Russet potatoes. In addition to an increase in red potato pounds purchased during the winter months, Figure 2.8 also shows three distinct increases in weekly pounds purchased at the end of March 2006, 2007, and 2008, respectively. This may be explained due to the proximity of Easter Sunday. New York generally purchased more pounds of red potatoes per week as indicated by Figure 2.8.

Similar to the seasonal patterns observed for red potato purchases presented in Figure 2.8, Figure 2.10 also show an increase in creamer pounds purchased at the end of March 2006, 2007, and 2008, respectively. These increases in creamer pounds purchased can be most easily identified in New York and Chicago. Again, this can be explained by the proximity to Easter Sunday. Figure 2.11 also shows some indication of an increase in organic potato pounds purchased during November and December of 2006, most notably in Atlanta and New York. Figure 2.9 shows the weekly pounds purchased for Idaho potatoes during the data collection period. It is observed from this figure that Idaho potatoes experienced a significant increase in pounds purchased from September 2006 through the end of June 2007. This increase is most notable in Atlanta and New York during this time period. However, what was unexpected about this figure was that the weekly pounds purchased for Idaho potatoes continued to stay relatively flat after June 2007. There was a slight increase in weekly pounds sold during November 2007, but nowhere near the volumes purchased in November and December 2006. In fact, the largest volume of weekly pounds purchased in late December 2007 was roughly half of what was observed one year prior. One explanation of this observation references a study by Bolotova et al. (2010), which found evidence on the effectiveness of a marketing supply stabilization program developed by an Idaho marketing cooperative. This program coordinated output by taking acreage out of potato production, and controlled the flow of supply through a coordinate marketing effort. Bolotova et al. (2010) found that the program was very effective at managing volatile prices.  Although the marketing supply stabilization program was implemented in late 2005, the weekly quantity purchases of Idaho potatoes presented in Figure 2.9 may very well not have been impacted until the program had become more developed. Figure 2.12 also provides evidence of the cooperative program's impacts on the price per pound for Idaho potatoes in this study. Although difficult to pinpoint exact timing, the weekly price per pound of Idaho potatoes began to rise roughly at the start of 2008 for all five cities in the dataset.

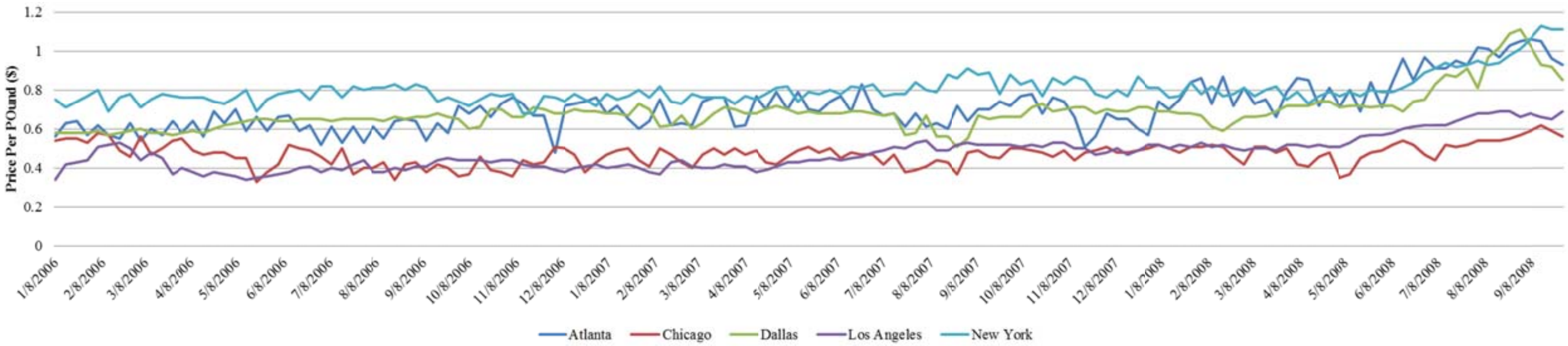


**Figure 2.12: Weekly Price of Idaho Potatoes by City from January 8, 2006 to September 28, 2008**

What none of these measures accurately reflects, but will prove to be an important component of this study, is how sensitive consumers are to changes in price and expenditure. The goal of the econometric estimation in this study is to compare the own-price elasticities and expenditure elasticities between the five cities. The panel nature of the data, along with the differences in price, quantities purchased, and the expenditure share by variety between the five cities could lead the econometric model in a direction of heavy use of dummy variables. By developing one system of demand equations and assigning a dummy variable for each of the five cities, the model will not capture the city specific elasticities and may lead to specification bias. If this modeling path were chosen, the estimated coefficient on the city specific dummy variable would only describe an intercept change relative to the reference city group. To obtain estimated price and expenditure elasticities, the data would need to be divided and estimated on a per city basis. This justified the estimation of five systems of demand equations; one for each of the five cities in the panel.

2.5 The Empirical System of Demand Equations for Potato Varieties

Using Deaton and Muellbauer's linear approximate almost ideal demand system, an eight equation potato demand system for each of the five cities in the dataset is estimated. This study assumes that the potato category is weakly separable from all other goods which allows for estimation of the last stage of a multi-stage budgeting process (Edgerton, 1997). By estimating a demand system for each city, the price and expenditure elasticities can be compared to determine if differences in demand exist between the cities. The demand system model used in this study is characterized by equation (13).

$$w_{it} = \alpha_i + \sum_{j=1}^{8} \gamma_{ij} ln(P_{jt}) + \beta_i \, ln\left(\frac{X_t}{P_t}\right) +$$

$$\psi_{ih} Holiday_t + +\delta_i Trend_t + \lambda_i Rice_{it} + \mu_i Pasta_{it} \qquad (12)$$

In the above equation, *i* equals the eight potato varieties at time *t*: yellow, white, Russet, fingerling, red, Idaho, creamer, and organic. The dependent variable ($w_{it}$) is the expenditure share for the $i^{th}$ potato variety, and the variable $\ln(P_j)$ denotes the price of each of the eight potato varieties in the potato category. The variable $ln\left(\frac{X_t}{P_t}\right)$ includes both the total expenditure on the potato category, $ln(X_t)$, and Stone's price index, $\ln(P_t) = \sum_i w_{it-1} \ln(P_{it})$.

Because the data is time series in nature, seasonal and habit forming effects of consumption may be observed. Based on the relative search frequency data from Google Trends, people in each of the five cities tended to search for "potato" at a higher frequency during the weeks prior to and containing a major American holiday (see Appendix B for the results from the Google Trends data) (Google Inc., 2012). Bond and Richards (2008) discussed the importance of the seasonality of consumption, especially during the winter months of the year. In their model, they used annual quarterly dummy variables as well as holiday dummy variables to capture these effects. Other studies have also used a holiday dummy variable to explain potential changes in consumption near holidays (Alston, et al., 1997; Chang et al., 2011; Vickner, et al., 2000). Following the work from these previous studies, a holiday dummy variable was included in the model. Shown in equation (8), the dummy variable labeled as $Holiday_t$ equals one during the weeks immediately prior to and containing Easter, the 4$^{th}$ of July, Thanksgiving, and Christmas, and equals zero otherwise. This study did not include annual quarterly dummy variables due to concerns of collinearity with the holiday dummy.

Due to interest in moment and habit forming effects of potato consumption, a trend variable, denoted as $Trend_t$, was included. Moschini and Meilke (1989) suggest using a specific form of this variable (see Richards, Kagan and Gao, 1997 and Chang et al., 2010 as an example for this type of trend variable). Here, the trend variable equals $t/T$, for $t$ = 0 to $T$. This allows the trend variable to be bounded on a [0,1] interval. For this study, the first weekly observation equals 0/142, while the last weekly observation equals 142/142.

The final explanatory variables included in the model are the logged prices of rice and pasta. However, as discussed in section 1.2 of this paper, there exists some debate to the role of the price of other goods (carbohydrate goods) on potato consumption (see Richards, Kagan, and Gao, 1997; Hsieh et al. 2009; Bond and Richards, 2008). Richards, Kagan and Gao (1997) and Hsieh et al. (2009) found complementary effects between potatoes consumption and rice and pasta. Bond and Richards (2008) found very weak or no significant effects on the price rice and pasta with respect to potato demand at the category level. However, the Colorado Potato

Administrative Committee and other members of the potato industry have expressed interest in the emergence of carbohydrate substitutes as competition to potatoes.

Though, not formally represented in the econometric model shown in (8), a lagged expenditure share was included in the econometric estimation procedure. Deaton and Muellbauer’s 1980 paper discussed variables that may be included in the budget share equation to help control autocorrelation. In addition to a lagged budget share explanatory variable, they also suggested including a time trend variable or variable to capture stocks of the good in question.

The final specification of the system for modeling demand for potato varieties requires constraints on the parameters (13):

$$\sum_{i} \alpha_i = 1, \;\; and$$

$$\sum_{i=1} \gamma_i = \sum_{i=1} \beta_i = \sum_{i=1} \psi_i = \sum_{i=1} \delta_i = \sum_{i=1} \lambda_i = \sum_{i=1} \mu_i = 0 \qquad (13)$$

which maintains the adding-up condition (14):

$$\sum_{i} w_i \equiv 1 \qquad (14).$$

Restrictions to be tested and imposed are homogeneity (15) and symmetry (16):

$$\sum_j \gamma_{ij} = 0 \tag{15}$$

$$\gamma_{ij} = \gamma_{ji} \tag{16}$$

The parameter results from the linear approximate almost ideal demand system (12) will be presented in section 3.4. The price and expenditure elasticities will be presented in section 3.5.

CHAPTER 3: TESTS AND RESULTS

3.1 Homogeneity and Symmetry

The restrictions implied by the symmetry of the price-response matrix form a Wald test statistic that is chi-square distributed with the degrees of freedom equal to the number of constraints. With twenty-one degrees of freedom at the 1% level of significance, the critical chi-square value for this test is 35.48 for each system of equations. The test statistic values for each of the systems are 107.81, 36.20, 73.15, 42.47, and 90.57 for Atlanta, Chicago, Dallas, Los Angeles, and New York, respectively. Thus, the null hypothesis of symmetry was rejected for each of the five systems at the 1% level of significance.

The restrictions implied by homogeneity require the sum of the price parameters for each equation to equal zero. An F-test was used to test the null hypothesis that $\sum_j \gamma_{ij} = 0$. The critical F-value value at the 5% and 1% level of significance are 3.91 and 6.82, respectively. Table 3.1 presents the test statistic values for each equation in the five systems along with statistical significance.

Table 3.1: Homogeneity Test Statistics by Expenditure Equation Per System

| Equation | Atlanta | Chicago | Dallas | Los Angeles | New York |
|---|---|---|---|---|---|
| yellow | 7.16** | 0.32 | 0.01 | 6.43* | 0.06 |
| white | 0.77 | 1.66 | 0.12 | 0.32 | 0.85 |
| Russet | 8.26** | 0.16 | 3.41 | 0.75 | 0.33 |
| fingerling | 14.39** | 0.8 | 1.56 | 15.61** | 0.88 |
| red | 14.19** | 1.57 | 6.2 | 0.99 | 1.09 |
| Idaho | 14.48** | 0.66 | 14.11** | 3.85* | 6.49* |
| creamer | 0.01 | 1.13 | 1.06 | 1.71 | 7.83** |
| organic | 0.09 | 12.79** | 2.04 | 0.13 | 7.90** |

*: p<0.05; **: p<0.01

Homogeneity was rejected in at least one expenditure share equation for in each of the five systems. According to Deaton and Muellbauer (1980) and Duffy (2003) the rejection of the homogeneity and symmetry restrictions are due to attempting to model dynamic behavior in a static system. Remedial methods will be discussed later in greater detail, but rejection of these theoretical restrictions is common in empirical work, as noted by Duffy (2003).

### 3.2 Endogenous Prices

The individual potato prices for each system may be correlated with the error term in each expenditure equation due to unobserved heterogeneity driving changes in prices. The instrumental variable method was used to test for the existence of endogenous prices within the systems. Two sets of instruments were considered candidates for this test. The first method takes advantage of the panel nature of the data, while the second method uses the one-period lagged endogenous variable as the instrument. Another method that was not explored in this study involves the explicit specification of price equations, which reflect strategic firm behavior and supply cost (see Kadiyali, Vilcussium and Chintagunta, 1996).

The first method used in this study applies the econometric methodology developed in Hausman and Taylor (1981), which was then used in an empirical demand system framework assessment in Hausman, Leonard, and Zona (1994). This approach takes advantage of the panel nature of the data to test for endogeneity. This technique instruments the endogenous prices in one city with the prices from the other cities in the panel at the same point in time. Hausman, Leonard, and Zona (1994) indicated that this approach is appropriate for products that are sold at wholesale national level at a relatively uniform price. This instrumental variable method assumes that the prices then seen at the individual city level reflect underlying product costs plus the city specific factors such as promotional strategies. The second method used in this study used the lagged logarithm of the potentially endogenous price within the system. Gujarati and Porter (2009) describe how lagged endogenous variables can be deemed predetermined in the current time period because they are nonstochastic.

Both instrumental variable methods in this study used Hausman's specification test (1978) to test for endogeneity of the potato prices in the system. This test requires a comparison of an estimator that is consistent under both the null and alternative but in not asymptotically efficient under the null, and one that is consistent and asymptotically efficient under the null. The iterative seemingly unrelated regression estimates of the system are compared to the iterative three-stage least squares estimates. Under the null hypothesis, the iterative seemingly unrelated regression estimates are consistent and asymptotically efficient, whereas the iterative three-stage least squares estimates are inefficient. The test statistic is:

$$(\beta_t - \beta_s)'[V(\beta_t) - V(\beta_s)]^{-1}(\beta_t - \beta_s) \sim \chi_q^2$$

where $q$ is the number of parameters associated with the endogenous variable, $\beta_t$ is the vector of the iterative three-stage least squares parameter estimates, $\beta_s$ is the vector of the iterative seemingly unrelated regression parameter estimates, and $V(\beta_t)$ and $V(\beta_s)$ are the covariance matrices for iterative three-stage least squares and iterative seeming unrelated regression, respectively. The null hypothesis for this test is price exogeneity (not endogenous); a rejection of this test indicates that prices are likely endogenous. With seven degrees of freedom, the critical value for this test is 15.51 at the 5% level of significance. Tables 3.2 and 3.3 show the test results from Hausman's Specification Test (1978) using Hausman and Taylor's (1981) instrumental variable method and the lagged endogenous instrumental variable method, respectively.

Table 3.2: Statistics for Hausman's Specification Test - Hausman and Taylor's Method

| *Equation* | Atlanta | Chicago | Dallas | Los Angeles | New York |
|---|---|---|---|---|---|
| yellow | 4.32 | 14.63 | 27.97* | 10.51 | 3.86 |
| white | 8.68 | 33.32* | 20.81* | 3.21 | 21.07* |
| Russet | 53.61* | 3.00 | 18.69* | 38.37* | 31.41* |
| fingerling | 0.15 | 5.20 | 13.79 | 2.38 | 0.02 |
| red | 23.95* | 20.85* | 14.29 | 18.39* | 24.02* |
| Idaho | 24.77* | 12.90 | 19.4* | 17.05* | 25.11* |
| creamer | 4.96 | 20.81* | 17.38* | 8.90 | -18.59 |
| organic | 19.99* | 28.24* | 6.54 | 18.6* | 8.65 |

*: $p<0.05$

Table 3.3: Statistics for Hausman's Specification Test - Lagged Endogenous Variables

| *Equation* | Atlanta | Chicago | Dallas | Los Angeles | New York |
|---|---|---|---|---|---|
| yellow | 20.04* | 15.8* | 10.47 | 17.43* | 17.22* |
| white | 13.16 | 40.81* | 24.52* | -4.56 | 41.26* |
| Russet | 29.49* | 3.71 | 16.44* | 19.59* | 43.04* |
| fingerling | 6.34 | -0.4 | 11.74 | 12.98 | -8.2 |
| red | 21.12* | 21.06* | -70.14 | 41.18* | 12.88 |
| Idaho | 22.51* | 23.63* | 63.33* | 19.87* | -0.67 |
| creamer | 11.25 | 18.17* | 9.86 | 9.1 | 6.72 |
| organic | 20.69* | -143.74 | 19.12* | 21.56* | 11.39 |

*: $p<0.05$

Shown in tables 3.2 and 3.3, the null hypothesis of price exogeneity was rejected for test values that were found to be greater than the critical value of 15.51. The results in the both tables rejected price exogeneity for at least three prices in each system. Comparing each set of results from the respective instruments shows agreement on rejecting price exogeneity in many instances. For example, both instrumental methods in the Atlanta system rejected exogeneity for the price of Russets, red, Idaho, and organic potatoes. In the Chicago system, the price of white, red, and creamer potatoes were found to be endogenous using both instrumental variable methods. Similarly in the Dallas system, the price of white, Russet, and Idaho potatoes were found to be endogenous; for Los Angeles, the price of Russet, red, Idaho, and organics were found to be endogenous; and lastly, in the New York system, the price of white and Russets were found to be endogenous.

Despite these consistencies, the test results using the two alternative instrumental variables also show discrepancies in testing price exogeneity.  For example, in the Atlanta system, Hausman's Specification Test (1978) using lagged endogenous instrumental variable method rejected price exogeneity for the price of yellow potatoes, while the Hausman and Taylor (1981) approach failed to reject exogeneity. This discrepancy was found in all five systems, and is likely due to the quality of the instrumental variables. Shown in table 3.3, the quality of the lagged endogenous variable as the instrument comes into question due to the sign of the test statistic. By definition, a chi-squared value must be greater than zero (Gujarati and Porter, 2009). Six test statistics in table 3.3 were found to have negative values: the price of fingerlings and organics in the Chicago system; the price of red in the Dallas system; the price of white in the Los Angeles system; and the price of fingerlings and Idaho in the New York System. Comparatively, the results from the alternative Hausman Specification Test using Hausman and Taylor's (1981) instrumental variable shown in table 3.2 shows only one test statistic with a negative value: the price of creamers in the New York system. Therefore, Hausman and Taylor's (1981) method for testing endogenous prices is preferred to the lagged endogenous variable alternative method, and will be used in correcting for endogenous prices throughout the remainder of this paper.

## 3.3 Autocorrelation and Dynamic Modeling

In the static linear approximate almost ideal demand system, it is implicitly assumed that that there is no difference between short-run and long-run behavior (Anderson and Blundell, 1982). In reality, habit persistence, adjustment costs, imperfect information, incorrect expectations, and misinterpreted real price changes may prevent the consumer from adjusting expenditure appropriately conditional on changes in prices and income. Evaluating time series data with the static linear approximate almost ideal demand system will likely result in rejection of the theoretical restriction of homogeneity and symmetry (Duffy, 2003). Deaton and Muellbauer's 1980 paper discussed how, if ignored, the dynamic component of the data generating process could lead to induced autocorrelation. To account for such dynamics and remove autocorrelation, Deaton and Muellbauer suggested the researcher include additional variables such as lagged budget shares or a time trend variable. For example, Blanciforti and Green (1983) incorporated habit formation in their almost ideal demand system by introducing a lagged budget share and a lagged consumption variable in each budget share equation. Deaton and Muellbauer (1980) proposed an alternative approach to incorporating dynamic behavior by estimating the linear approximate almost ideal demand system as a first-differenced form. Eales and Unnevehr's 1988 paper used this approach to model demand for beef and chicken. In their study, they compared the results from first-differenced model with static model that included a lagged budget share as an explanatory variable yielded "similar, but marginally inferior, results."

The tests for symmetry and homogeneity as discussed in section 3.1 suggest that, given the static nature of the linear approximate almost ideal demand system used in this study, the dynamic behavior in the data has not been correctly modeled. Imposing the homogeneity and symmetry restrictions likely are inducing autocorrelated errors in each equation for the five estimated systems. Knowing consequence of the using the static linear approximate almost ideal demand to model time series demand data justified the use of a lagged expenditure share as an explanatory variable in the expenditure share equations. Admittedly, a first-differenced linear approximate almost ideal demand system may prove to better model the data in this study (Eales and Unnevehr, 1988).

Additional restrictions are needed to fully correct for autocorrelation in a system of singular equations (Berndt and Savin, 1975). By substituting the vector autoregressive process into the model, the autocorrelation matrix can be parameterized to account for autocorrelated errors. Bertndt and Savin suggest that the autocorrelation matrix can include a single-parameter specification. Other authors have provided alternative parameterization specification techniques that allow for more general and more flexible alternatives, however, these techniques are not applied to the estimated demand system utilized in the current investigation. The implications of not applying these techniques in this study may be a reduction in efficiency of the estimates (Gujarati and Porter, 2009). Interested readers are encouraged to see Moschini and Moro (1994) and Holt (1998) for an outline of alternative parameterization techniques.

## 3.4 Parameter Estimates from the Linear Approximate Almost Ideal Demand System

The five linear approximate almost ideal demand systems were estimated three times; once using an iterative seemingly unrelated regression, and twice using two competing instrumental variable methods in an iterative three-stage least squares framework. Estimation of each system of demand equations was conducted using STATA 12. For each estimation procedure, the organic expenditure equation was dropped due to the singular nature of the system, but estimates can be easily be recovered via the restrictions imposed on the system shown in (9) in section 2.3 of this paper. Section 3.2 describes the Hausman specification test used to compared the iterative seeming unrelated regression parameter estimates with the iterative three-stage least squares parameter estimates using the two competing instrumental variable methods. The Hausman specification tests results shown in tables 3.2 and tables 3.3 indicated that each of the five systems of equations had endogenous prices. It was concluded upon comparing the test statistics shown in tables 3.2 and 3.3 that the instruments suggested by Hausman and Taylor (1981) and empirically applied by Hausman, Leonard, and Zona (1994) are better instruments relative to the competing lagged endogenous variable instruments due less occurrences of a negative chi-squared test statistic in the latter test. The three-stage least squares parameter estimates using the lagged endogenous variables as instruments will be included in the Appendix C to be made available for the reader's convenience.

The remainder of this section will compare select parameter estimates from the iterative three-stage least squares LA/AIDS model, which better corrected for endogeneity using Hausman and Taylor's approach, against the iterative seemingly unrelated regression model that did not correct for endogeneity. The goal of comparing the two estimation methods, with and without correcting for endogeneity, is to see if any significant differences exist between the parameter estimates given the existence of endogenous prices. The estimated elasticities from the two competing estimation methods will then be compared in section 3.5.

Tables 3.4 through 3.13 show the parameter estimates from the linear approximate almost ideal demand system used in this study. Each city has two tables of parameter estimates; one correcting for endogeneity, and one without. The standard errors are shown in parentheses below the parameter estimates, while * and ** indicate significance at the 5% and 1% respectively. The $R^2$ for the respective equations in each system are found at the bottom of each table.

Table 3.4: Atlanta Parameter Estimates Correcting for Endogenous Prices

| | yellow | white | Russet | fingerling | red | Idaho | creamer |
|---|---|---|---|---|---|---|---|
| $\ln(P_{yellow})$ | -0.074** | 0.004 | 0.014 | -0.001 | 0.016* | 0.032** | 0.013** |
| | (0.007) | (0.006) | (0.011) | (0.000) | (0.008) | (0.011) | (0.005) |
| $\ln(P_{white})$ | 0.004 | -0.072** | -0.004 | 0.001 | 0.027** | 0.039* | 0.001 |
| | (0.006) | (0.012) | (0.016) | (0.000) | (0.009) | (0.015) | (0.005) |
| $\ln(P_{Russet})$ | 0.014 | -0.004 | 0.027 | 0.001 | 0.021 | -0.080* | 0.005 |
| | (0.011) | (0.016) | (0.043) | (0.001) | (0.017) | (0.035) | (0.010) |
| $\ln(P_{fingerling})$ | -0.001 | 0.001 | 0.001 | -0.001** | -0.001 | 0.001 | -0.001 |
| | (0.000) | (0.000) | (0.001) | (0.000) | (0.001) | (0.001) | (0.001) |
| $\ln(P_{red})$ | 0.016* | 0.027** | 0.021 | -0.001 | -0.084** | 0.006 | 0.013 |
| | (0.008) | (0.009) | (0.017) | (0.001) | (0.018) | (0.018) | (0.008) |
| $\ln(P_{Idaho})$ | 0.032** | 0.039* | -0.080* | 0.001 | 0.006 | 0.012 | -0.005 |
| | (0.011) | (0.015) | (0.035) | (0.001) | (0.018) | (0.042) | (0.010) |
| $\ln(P_{creamer})$ | 0.013** | 0.001 | 0.005 | -0.001 | 0.013 | -0.005 | -0.024** |
| | (0.005) | (0.005) | (0.010) | (0.001) | (0.008) | (0.010) | (0.008) |
| $\ln(P_{organic})$ | -0.006 | 0.003 | 0.016 | 0.001 | 0.001 | -0.005 | -0.003 |
| | (0.005) | (0.007) | (0.015) | (0.000) | (0.008) | (0.014) | (0.005) |
| ln(X/P) | 0.029** | -0.005 | 0.022 | -0.001 | -0.033* | -0.035 | -0.011 |
| | (0.010) | (0.017) | (0.041) | (0.001) | (0.014) | (0.043) | (0.008) |
| holiday | -0.004 | -0.011 | 0.007 | 0.001 | 0.010* | -0.003 | 0.002 |
| | (0.003) | (0.006) | (0.014) | (0.000) | (0.005) | (0.016) | (0.003) |
| trend | 0.059** | -0.011 | -0.028 | 0.001* | 0.008 | -0.032 | 0.012* |
| | (0.007) | (0.012) | (0.026) | (0.000) | (0.010) | (0.029) | (0.006) |
| $\ln(P_{rice})$ | -0.022 | -0.116** | 0.232** | -0.002 | -0.047* | -0.038 | -0.019 |
| | (0.015) | (0.027) | (0.063) | (0.001) | (0.022) | (0.064) | (0.013) |
| $\ln(P_{pasta})$ | -0.089** | 0.180** | -0.105 | 0.002 | 0.037 | -0.048 | 0.016 |
| | (0.018) | (0.033) | (0.074) | (0.001) | (0.026) | (0.080) | (0.014) |
| $w_{t-1}$ | 0.321** | 0.547** | 0.560** | 0.704** | 0.308** | 0.518** | 0.442** |
| | (0.045) | (0.041) | (0.042) | (0.061) | (0.046) | (0.042) | (0.066) |
| Constant | -0.355** | 0.043 | -0.035 | 0.006 | 0.507** | 0.603 | 0.179 |
| | (0.128) | (0.229) | (0.552) | (0.008) | (0.184) | (0.584) | (0.106) |
| $R^2$ | 0.738 | 0.785 | 0.703 | 0.874 | 0.558 | 0.539 | 0.524 |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.5 Atlant Parameter Estimates Without Correcting for Endogenous Prices

| | yellow | white | Russet | fingerling | red | Idaho | creamer |
|---|---|---|---|---|---|---|---|
| $\ln(P_{yellow})$ | -0.068** | 0.006 | 0.010 | -0.001 | 0.013* | 0.030** | 0.012** |
| | (0.007) | (0.006) | (0.006) | (0.000) | (0.005) | (0.007) | (0.004) |
| $\ln(P_{white})$ | 0.006 | -0.076** | 0.006 | 0.001* | 0.033** | 0.024* | -0.001 |
| | (0.006) | (0.012) | (0.011) | (0.000) | (0.007) | (0.011) | (0.005) |
| $\ln(P_{Russet})$ | 0.010 | 0.006 | -0.032 | 0.001 | 0.009 | -0.017 | 0.005 |
| | (0.006) | (0.011) | (0.023) | (0.000) | (0.008) | (0.020) | (0.005) |
| $\ln(P_{fingerling})$ | -0.001 | 0.001* | 0.001 | -0.001** | 0.001 | 0.001 | -0.001 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) |
| $\ln(P_{red})$ | 0.013* | 0.033** | 0.009 | 0.001 | -0.115** | 0.033** | 0.018** |
| | (0.005) | (0.007) | (0.008) | (0.000) | (0.008) | (0.009) | (0.005) |
| $\ln(P_{Idaho})$ | 0.030** | 0.024* | -0.017 | 0.001 | 0.033** | -0.073** | 0.004 |
| | (0.007) | (0.011) | (0.020) | (0.000) | (0.009) | (0.024) | (0.006) |
| $\ln(P_{creamer})$ | 0.012** | -0.001 | 0.005 | -0.001 | 0.018** | 0.004 | -0.035** |
| | (0.004) | (0.005) | (0.005) | (0.001) | (0.005) | (0.006) | (0.007) |
| $\ln(P_{organic})$ | -0.003 | 0.006 | 0.019** | -0.001 | 0.008* | 0.001 | -0.004 |
| | (0.003) | (0.005) | (0.007) | (0.000) | (0.004) | (0.007) | (0.003) |
| ln(X/P) | 0.030** | 0.006 | -0.023 | -0.001 | -0.036** | 0.015 | -0.010 |
| | (0.009) | (0.016) | (0.036) | (0.001) | (0.012) | (0.038) | (0.007) |
| holiday | -0.005 | -0.013* | 0.016 | 0.001 | 0.011* | -0.014 | 0.002 |
| | (0.003) | (0.006) | (0.014) | (0.000) | (0.004) | (0.014) | (0.002) |
| trend | 0.056** | -0.007 | -0.050* | 0.001** | 0.003 | -0.008 | 0.010* |
| | (0.007) | (0.011) | (0.023) | (0.000) | (0.008) | (0.025) | (0.005) |
| $\ln(P_{rice})$ | -0.017 | -0.129** | 0.305** | -0.002* | -0.029 | -0.101 | -0.020 |
| | (0.013) | (0.025) | (0.056) | (0.001) | (0.017) | (0.057) | (0.010) |
| $\ln(P_{pasta})$ | -0.088** | 0.194** | -0.155* | 0.003* | 0.017 | -0.001 | 0.014 |
| | (0.017) | (0.032) | (0.070) | (0.001) | (0.023) | (0.074) | (0.013) |
| $w_{t-1}$ | 0.338** | 0.531** | 0.523** | 0.728** | 0.334** | 0.503** | 0.453** |
| | (0.041) | (0.038) | (0.035) | (0.052) | (0.040) | (0.037) | (0.064) |
| Constant | -0.369** | -0.102 | 0.621 | 0.010 | 0.554** | -0.118 | 0.178 |
| | (0.117) | (0.211) | (0.486) | (0.007) | (0.159) | (0.512) | (0.095) |
| $R^2$ | 0.740 | 0.788 | 0.717 | 0.879 | 0.595 | 0.586 | 0.532 |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.6: Chicago Parameter Estimates Correcting for Endogenous Prices

| | yellow | white | Russet | fingerling | red | Idaho | creamer |
|---|---|---|---|---|---|---|---|
| $\ln(P_{yellow})$ | -0.071** | 0.010 | 0.042** | 0.001 | -0.019 | 0.004 | 0.037** |
| | (0.012) | (0.013) | (0.010) | (0.001) | (0.016) | (0.012) | (0.012) |
| $\ln(P_{white})$ | 0.010 | -0.034 | 0.004 | -0.002 | 0.046* | 0.001 | -0.025 |
| | (0.013) | (0.024) | (0.012) | (0.002) | (0.021) | (0.014) | (0.017) |
| $\ln(P_{Russet})$ | 0.042** | 0.004 | -0.102** | -0.001 | 0.019 | 0.008 | 0.033** |
| | (0.010) | (0.012) | (0.021) | (0.001) | (0.018) | (0.016) | (0.012) |
| $\ln(P_{fingerling})$ | 0.001 | -0.002 | -0.001 | -0.002 | 0.001 | 0.002 | 0.003* |
| | (0.001) | (0.002) | (0.001) | (0.001) | (0.002) | (0.001) | (0.001) |
| $\ln(P_{red})$ | -0.019 | 0.046* | 0.019 | 0.001 | -0.046 | -0.016 | -0.006 |
| | (0.016) | (0.021) | (0.018) | (0.002) | (0.036) | (0.021) | (0.021) |
| $\ln(P_{Idaho})$ | 0.004 | 0.001 | 0.008 | 0.002 | -0.016 | -0.009 | 0.010 |
| | (0.012) | (0.014) | (0.016) | (0.001) | (0.021) | (0.026) | (0.014) |
| $\ln(P_{creamer})$ | 0.037** | -0.025 | 0.033** | 0.003* | -0.006 | 0.010 | -0.044* |
| | (0.012) | (0.017) | (0.012) | (0.001) | (0.021) | (0.014) | (0.018) |
| $\ln(P_{organic})$ | -0.004 | 0.001 | -0.003 | -0.001 | 0.022* | 0.001 | -0.008 |
| | (0.005) | (0.007) | (0.004) | (0.001) | (0.009) | (0.004) | (0.006) |
| ln(X/P) | 0.006 | -0.067** | -0.009 | -0.001 | 0.032* | 0.025 | 0.022* |
| | (0.010) | (0.010) | (0.017) | (0.001) | (0.016) | (0.018) | (0.010) |
| holiday | -0.002 | 0.002 | -0.010 | 0.001 | 0.016* | -0.004 | -0.005 |
| | (0.005) | (0.005) | (0.009) | (0.000) | (0.008) | (0.009) | (0.005) |
| trend | 0.053** | -0.024** | 0.143** | 0.001 | -0.102** | -0.075** | -0.003 |
| | (0.011) | (0.012) | (0.019) | (0.001) | (0.017) | (0.017) | (0.013) |
| $\ln(P_{rice})$ | -0.056* | -0.017 | 0.079 | 0.001 | 0.106** | -0.054 | -0.053 |
| | (0.023) | (0.023) | (0.042) | (0.002) | (0.037) | (0.039) | (0.025) |
| $\ln(P_{pasta})$ | 0.011 | -0.007 | -0.170** | 0.000 | 0.032 | 0.093 | 0.046 |
| | (0.030) | (0.028) | (0.054) | (0.002) | (0.048) | (0.050) | (0.031) |
| $w_{t-1}$ | 0.333** | 0.325** | 0.287** | 0.507** | 0.322** | 0.2812** | 0.325** |
| | (0.032) | (0.031) | (0.031) | (0.067) | (0.029) | (0.031) | (0.032) |
| Constant | -0.059 | 1.049** | 0.280 | 0.015 | -0.197 | -0.270 | -0.244 |
| | (0.133) | (0.132) | (0.235) | (0.008) | (0.216) | (0.246) | (0.141) |
| $R^2$ | 0.480 | 0.722 | 0.632 | 0.555 | 0.565 | 0.524 | 0.584 |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.7: Chicago Parameter Estimates Without Correcting for Endogenous Prices

| | yellow | white | Russet | fingerling | red | Idaho | creamer |
|---|---|---|---|---|---|---|---|
| $\ln(P_{yellow})$ | -0.078** | 0.009 | 0.037** | -0.001 | 0.011 | -0.003 | 0.022** |
| | (0.010) | (0.007) | (0.010) | (0.001) | (0.009) | (0.011) | (0.006) |
| $\ln(P_{white})$ | 0.009 | -0.027** | 0.012 | 0.001 | 0.020* | -0.004 | -0.007 |
| | (0.007) | (0.009) | (0.009) | (0.000) | (0.009) | (0.010) | (0.006) |
| $\ln(P_{Russet})$ | 0.037** | 0.012 | -0.109** | -0.001 | 0.030* | 0.004 | 0.028** |
| | (0.010) | (0.009) | (0.020) | (0.001) | (0.014) | (0.016) | (0.009) |
| $\ln(P_{fingerling})$ | -0.001 | 0.001 | -0.001 | -0.002** | 0.001 | 0.001* | 0.001* |
| | (0.001) | (0.000) | (0.001) | (0.001) | (0.001) | (0.001) | (0.000) |
| $\ln(P_{red})$ | 0.011 | 0.020* | 0.030* | 0.001 | -0.120** | 0.009 | 0.040** |
| | (0.009) | (0.009) | (0.014) | (0.001) | (0.017) | (0.015) | (0.009) |
| $\ln(P_{Idaho})$ | -0.003 | -0.004 | 0.004 | 0.001* | 0.009 | -0.014 | -0.001 |
| | (0.011) | (0.010) | (0.016) | (0.001) | (0.015) | (0.023) | (0.010) |
| $\ln(P_{creamer})$ | 0.022** | -0.007 | 0.028** | 0.001* | 0.040** | -0.001 | -0.083** |
| | (0.006) | (0.006) | (0.009) | (0.000) | (0.009) | (0.010) | (0.008) |
| $\ln(P_{organic})$ | 0.002 | -0.003 | -0.002 | -0.001 | 0.009** | 0.008** | -0.001 |
| | (0.002) | (0.002) | (0.003) | (0.000) | (0.003) | (0.003) | (0.002) |
| ln(X/P) | 0.009 | -0.070** | -0.009 | -0.001 | 0.023 | 0.025 | 0.030** |
| | (0.009) | (0.009) | (0.017) | (0.000) | (0.013) | (0.017) | (0.009) |
| holiday | -0.001 | -0.001 | -0.009 | 0.001 | 0.015* | -0.003 | -0.004 |
| | (0.005) | (0.004) | (0.009) | (0.000) | (0.007) | (0.008) | (0.005) |
| trend | 0.048** | -0.016 | 0.140** | -0.001 | -0.087* | -0.077** | -0.019** |
| | (0.010) | (0.009) | (0.018) | (0.001) | (0.014) | (0.017) | (0.010) |
| $\ln(P_{rice})$ | -0.051* | -0.025 | 0.086* | 0.002 | 0.087** | -0.050 | -0.039 |
| | (0.022) | (0.021) | (0.042) | (0.001) | (0.032) | (0.038) | (0.022) |
| $\ln(P_{pasta})$ | -0.001 | 0.001 | -0.175** | -0.001 | 0.069 | 0.081 | 0.025 |
| | (0.028) | (0.026) | (0.053) | (0.001) | (0.041) | (0.049) | (0.028) |
| $w_{t-1}$ | 0.335** | 0.316** | 0.300** | 0.493** | 0.329** | 0.294** | 0.335** |
| | (0.029) | (0.028) | (0.027) | (0.059) | (0.027) | (0.028) | (0.028) |
| Constant | -0.086 | 1.058** | 0.279 | 0.018** | -0.122 | -0.265 | -0.304* |
| | (0.127) | (0.122) | (0.233) | (0.007) | (0.183) | (0.237) | (0.124) |
| $R^2$ | 0.512 | 0.727 | 0.634 | 0.611 | 0.652 | 0.542 | 0.638 |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.8: Dallas Parameter Estimates Correcting for Endogenous Prices

| | yellow | white | Russet | fingerling | red | Idaho | creamer |
|---|---|---|---|---|---|---|---|
| $\ln(P_{yellow})$ | -0.030 | 0.007 | 0.002 | -0.001 | 0.003 | 0.021 | -0.001 |
| | (0.011) | (0.004) | (0.010) | (0.002) | (0.007) | (0.012) | (0.005) |
| $\ln(P_{white})$ | 0.007 | 0.009* | 0.010 | -0.004** | 0.003 | -0.012 | -0.006 |
| | (0.004) | (0.004) | (0.005) | (0.001) | (0.004) | (0.007) | (0.003) |
| $\ln(P_{Russet})$ | 0.002 | 0.010 | -0.021 | 0.003 | 0.001 | -0.003 | -0.001 |
| | (0.010) | (0.005) | (0.028) | (0.002) | (0.011) | (0.019) | (0.006) |
| $\ln(P_{fingerling})$ | -0.001 | -0.004** | 0.003 | -0.004** | 0.005** | 0.002 | 0.002 |
| | (0.002) | (0.001) | (0.002) | (0.001) | (0.002) | (0.003) | (0.001) |
| $\ln(P_{red})$ | 0.003 | 0.003 | 0.001 | 0.005** | -0.047** | 0.024* | 0.009* |
| | (0.007) | (0.004) | (0.011) | (0.002) | (0.010) | (0.011) | (0.004) |
| $\ln(P_{Idaho})$ | 0.021 | -0.012 | -0.003 | 0.002 | 0.024* | -0.038 | 0.003 |
| | (0.012) | (0.007) | (0.019) | (0.003) | (0.011) | (0.022) | (0.007) |
| $\ln(P_{creamer})$ | -0.001 | -0.006 | -0.001 | 0.002 | 0.009* | 0.003 | -0.007 |
| | (0.005) | (0.003) | (0.006) | (0.001) | (0.004) | (0.007) | (0.008) |
| $\ln(P_{organic})$ | -0.001 | -0.006** | 0.009** | -0.003** | 0.003 | 0.003 | 0.001 |
| | (0.003) | (0.002) | (0.002) | (0.001) | (0.002) | (0.004) | (0.002) |
| $\ln(X/P)$ | 0.020* | -0.021** | 0.034 | -0.001 | -0.021* | -0.009 | -0.007 |
| | (0.009) | (0.004) | (0.021) | (0.002) | (0.009) | (0.015) | (0.004) |
| holiday | -0.004 | -0.003* | 0.005 | 0.001 | 0.008** | -0.007 | 0.001 |
| | (0.003) | (0.001) | (0.007) | (0.001) | (0.003) | (0.005) | (0.001) |
| trend | 0.008 | -0.003 | 0.017 | 0.001 | -0.014** | -0.013 | 0.007** |
| | (0.005) | (0.003) | (0.012) | (0.001) | (0.005) | (0.009) | (0.003) |
| $\ln(P_{rice})$ | -0.016 | 0.007 | 0.176** | -0.007** | -0.035** | -0.103** | -0.017** |
| | (0.014) | (0.006) | (0.032) | (0.003) | (0.013) | (0.022) | (0.007) |
| $\ln(P_{pasta})$ | 0.001 | -0.009 | -0.113** | 0.007* | 0.028 | 0.063* | 0.014 |
| | (0.017) | (0.008) | (0.041) | (0.003) | (0.017) | (0.028) | (0.008) |
| $w_{t-1}$ | 0.544** | 0.532** | 0.537** | 0.597** | 0.510** | 0.549** | 0.530** |
| | (0.027) | (0.029) | (0.026) | (0.044) | (0.027) | (0.028) | (0.039) |
| Constant | -0.259* | 0.327** | -0.168 | 0.006 | 0.338** | 0.155 | 0.111 |
| | (0.120) | (0.057) | (0.281) | (0.023) | (0.124) | (0.207) | (0.057) |
| $R^2$ | 0.653 | 0.725 | 0.699 | 0.758 | 0.580 | 0.821 | 0.775 |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.9: Dallas Parameter Estimates Without Correcting for Endogenous Prices

| | yellow | white | Russet | fingerling | red | Idaho | creamer |
|---|---|---|---|---|---|---|---|
| $\ln(P_{yellow})$ | -0.024** | 0.003 | 0.009 | -0.003** | 0.003 | 0.011 | -0.001 |
| | (0.006) | (0.002) | (0.007) | (0.001) | (0.005) | (0.007) | (0.002) |
| $\ln(P_{white})$ | 0.003 | 0.014** | 0.001 | -0.002 | -0.001 | -0.006 | -0.007** |
| | (0.002) | (0.003) | (0.004) | (0.001) | (0.003) | (0.004) | (0.002) |
| $\ln(P_{Russet})$ | 0.009 | 0.001 | -0.045** | 0.001 | 0.006 | 0.018 | 0.005 |
| | (0.007) | (0.004) | (0.021) | (0.002) | (0.009) | (0.013) | (0.004) |
| $\ln(P_{fingerling})$ | -0.003* | -0.002 | 0.001 | -0.003** | 0.004** | 0.003 | 0.002 |
| | (0.001) | (0.001) | (0.002) | (0.001) | (0.002) | (0.002) | (0.001) |
| $\ln(P_{red})$ | 0.003 | -0.001 | 0.006 | 0.004** | -0.049** | 0.028** | 0.008* |
| | (0.005) | (0.003) | (0.009) | (0.002) | (0.009) | (0.008) | (0.004) |
| $\ln(P_{Idaho})$ | 0.011 | -0.006 | 0.018 | 0.003 | 0.028** | -0.062** | 0.007 |
| | (0.007) | (0.004) | (0.013) | (0.002) | (0.008) | (0.014) | (0.004) |
| $\ln(P_{creamer})$ | -0.001 | -0.007** | 0.005 | 0.002 | 0.008* | 0.007 | -0.018** |
| | (0.002) | (0.002) | (0.004) | (0.001) | (0.004) | (0.004) | (0.005) |
| $\ln(P_{organic})$ | 0.001 | -0.004** | 0.006** | -0.002** | 0.001 | 0.002 | 0.002 |
| | (0.001) | (0.001) | (0.002) | (0.001) | (0.002) | (0.002) | (0.002) |
| $\ln(X/P)$ | 0.025** | -0.025** | 0.026 | -0.001 | -0.021* | -0.003 | -0.005 |
| | (0.008) | (0.004) | (0.020) | (0.001) | (0.009) | (0.013) | (0.003) |
| holiday | -0.004 | -0.003* | 0.008 | 0.001 | 0.008** | -0.009 | -0.001 |
| | (0.003) | (0.001) | (0.007) | (0.000) | (0.003) | (0.005) | (0.001) |
| trend | 0.008 | -0.001 | 0.010 | 0.001 | -0.016** | -0.008 | 0.008** |
| | (0.005) | (0.002) | (0.012) | (0.001) | (0.005) | (0.008) | (0.002) |
| $\ln(P_{rice})$ | -0.013 | 0.004 | 0.190** | -0.008** | -0.037** | -0.109** | -0.024** |
| | (0.012) | (0.005) | (0.030) | (0.002) | (0.013) | (0.020) | (0.006) |
| $\ln(P_{pasta})$ | -0.004 | -0.007 | -0.107** | 0.007* | 0.029 | 0.058* | 0.019** |
| | (0.015) | (0.007) | (0.040) | (0.003) | (0.017) | (0.026) | (0.007) |
| $w_{t-1}$ | 0.541** | 0.535** | 0.540** | 0.604** | 0.515** | 0.555** | 0.513** |
| | (0.025) | (0.027) | (0.024) | (0.042) | (0.025) | (0.025) | (0.033) |
| Constant | -0.329** | 0.375** | -0.054 | 0.014 | 0.343** | 0.058 | 0.091* |
| | (0.104) | (0.048) | (0.266) | (0.020) | (0.117) | (0.181) | (0.046) |
| $R^2$ | 0.663 | 0.750 | 0.706 | 0.758 | 0.570 | 0.826 | 0.775 |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.10: Los Angeles Parameter Estimates Correcting for Endogenous Prices

| | yellow | white | Russet | fingerling | red | Idaho | creamer |
|---|---|---|---|---|---|---|---|
| $\ln(P_{yellow})$ | -0.011* | -0.002 | 0.001 | -0.001 | -0.004 | 0.012** | 0.003 |
| | (0.005) | (0.004) | (0.008) | (0.001) | (0.007) | (0.004) | (0.003) |
| $\ln(P_{white})$ | -0.002 | -0.003 | -0.017 | -0.001 | 0.029** | -0.005 | 0.002 |
| | (0.004) | (0.006) | (0.009) | (0.001) | (0.010) | (0.005) | (0.004) |
| $\ln(P_{Russet})$ | 0.001 | -0.017 | -0.130** | -0.001 | 0.023 | 0.108** | 0.010 |
| | (0.008) | (0.009) | (0.032) | (0.002) | (0.022) | (0.016) | (0.008) |
| $\ln(P_{fingerling})$ | -0.001 | -0.001 | -0.001 | -0.004* | 0.004 | -0.001 | 0.001 |
| | (0.001) | (0.001) | (0.002) | (0.002) | (0.002) | (0.001) | (0.002) |
| $\ln(P_{red})$ | -0.004 | 0.029** | 0.023 | 0.004* | -0.042 | 0.001 | -0.007 |
| | (0.007) | (0.010) | (0.022) | (0.002) | (0.024) | (0.012) | (0.008) |
| $\ln(P_{Idaho})$ | 0.012** | -0.005 | 0.108** | -0.001 | 0.001 | -0.119** | 0.002 |
| | (0.004) | (0.005) | (0.016) | (0.001) | (0.012) | (0.013) | (0.005) |
| $\ln(P_{creamer})$ | 0.003 | 0.002 | 0.010 | 0.001 | -0.007 | 0.002 | -0.009 |
| | (0.003) | (0.004) | (0.008) | (0.002) | (0.008) | (0.005) | (0.006) |
| $\ln(P_{organic})$ | 0.001 | -0.002 | 0.008* | 0.003** | -0.003 | 0.001 | -0.002 |
| | (0.001) | (0.002) | (0.004) | (0.001) | (0.003) | (0.003) | (0.002) |
| ln(X/P) | 0.016** | -0.011** | -0.023 | -0.001 | -0.008 | 0.031** | -0.004 |
| | (0.003) | (0.004) | (0.013) | (0.000) | (0.009) | (0.009) | (0.003) |
| holiday | -0.001 | -0.001 | 0.006 | 0.001* | 0.001 | -0.004 | 0.000 |
| | (0.001) | (0.002) | (0.006) | (0.000) | (0.004) | (0.004) | (0.001) |
| trend | 0.018** | -0.008** | -0.020 | 0.000 | 0.012 | -0.006 | 0.002 |
| | (0.003) | (0.003) | (0.011) | (0.000) | (0.008) | (0.007) | (0.003) |
| $\ln(P_{rice})$ | -0.033** | 0.020* | 0.055 | -0.003 | -0.029 | 0.008 | -0.016* |
| | (0.006) | (0.008) | (0.024) | (0.001) | (0.018) | (0.015) | (0.007) |
| $\ln(P_{pasta})$ | -0.001 | -0.005 | -0.010 | 0.004** | 0.004 | 0.008 | 0.002 |
| | (0.006) | (0.009) | (0.029) | (0.001) | (0.021) | (0.019) | (0.006) |
| $w_{t-1}$ | 0.499** | 0.556** | 0.563** | 0.639** | 0.559** | 0.563** | 0.600** |
| | (0.028) | (0.027) | (0.026) | (0.065) | (0.027) | (0.026) | (0.033) |
| Constant | -0.237** | 0.191** | 0.629** | 0.009 | 0.169 | -0.417** | 0.082* |
| | (0.039) | (0.058) | (0.192) | (0.007) | (0.136) | (0.127) | (0.041) |
| $R^2$ | 0.874 | 0.609 | 0.855 | 0.760 | 0.244 | 0.932 | 0.424 |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.11: Los Angeles Parameter Estimates Without Correcting for Endogenous Prices

| | yellow | white | Russet | fingerling | red | Idaho | creamer |
|---|---|---|---|---|---|---|---|
| $\ln(P_{yellow})$ | -0.018** | -0.009** | 0.009* | 0.001 | 0.003 | 0.008** | 0.004 |
| | (0.004) | (0.003) | (0.005) | (0.001) | (0.004) | (0.003) | (0.003) |
| $\ln(P_{white})$ | -0.009** | -0.010* | -0.001 | -0.01* | 0.030** | -0.007 | 0.001 |
| | (0.003) | (0.005) | (0.006) | (0.000) | (0.006) | (0.004) | (0.003) |
| $\ln(P_{Russet})$ | 0.009* | -0.001 | -0.149** | 0.001 | 0.030* | 0.101** | 0.006 |
| | (0.005) | (0.006) | (0.022) | (0.001) | (0.014) | (0.011) | (0.005) |
| $\ln(P_{fingerling})$ | 0.001 | -0.001** | 0.000 | -0.005** | 0.001 | 0.001* | 0.003* |
| | (0.001) | (0.000) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| $\ln(P_{red})$ | 0.003 | 0.030** | 0.030* | 0.001 | -0.069** | 0.013 | -0.009* |
| | (0.004) | (0.006) | (0.014) | (0.001) | (0.014) | (0.008) | (0.004) |
| $\ln(P_{Idaho})$ | 0.008** | -0.007 | 0.101** | 0.001* | 0.013 | -0.119** | 0.002 |
| | (0.003) | (0.004) | (0.011) | (0.001) | (0.008) | (0.010) | (0.003) |
| $\ln(P_{creamer})$ | 0.004 | 0.001 | 0.006 | 0.003* | -0.009* | 0.002 | -0.008 |
| | (0.003) | (0.003) | (0.005) | (0.001) | (0.004) | (0.003) | (0.005) |
| $\ln(P_{organic})$ | 0.002* | -0.003** | 0.003* | 0.001 | 0.001 | 0.001 | 0.000 |
| | (0.001) | (0.001) | (0.002) | (0.000) | (0.001) | (0.001) | (0.001) |
| ln(X/P) | 0.016** | -0.010** | -0.025 | -0.001 | -0.005 | 0.030** | -0.004 |
| | (0.003) | (0.004) | (0.013) | (0.000) | (0.009) | (0.009) | (0.003) |
| holiday | -0.001 | -0.002 | 0.007 | 0.001 | -0.001 | -0.003 | -0.001 |
| | (0.001) | (0.002) | (0.006) | (0.000) | (0.004) | (0.004) | (0.001) |
| trend | 0.021** | -0.004 | -0.023* | 0.001 | 0.010 | -0.005 | 0.001 |
| | (0.002) | (0.003) | (0.010) | (0.000) | (0.007) | (0.006) | (0.002) |
| $\ln(P_{rice})$ | -0.035** | 0.014* | 0.060** | -0.002* | -0.034* | 0.010 | -0.014** |
| | (0.005) | (0.007) | (0.022) | (0.001) | (0.016) | (0.014) | (0.005) |
| $\ln(P_{pasta})$ | 0.003 | -0.004 | -0.012 | 0.001 | -0.001 | 0.012 | 0.002 |
| | (0.005) | (0.008) | (0.029) | (0.001) | (0.020) | (0.019) | (0.006) |
| $w_{t-1}$ | 0.515** | 0.584** | 0.588** | 0.712** | 0.584** | 0.584** | 0.608** |
| | (0.024) | (0.023) | (0.022) | (0.047) | (0.023) | (0.022) | (0.030) |
| Constant | -0.232** | 0.186** | 0.635** | 0.012* | 0.135 | -0.410** | 0.073 |
| | (0.037) | (0.056) | (0.192) | (0.005) | (0.133) | (0.126) | (0.040) |
| $R^2$ | 0.883 | 0.623 | 0.852 | 0.845 | 0.261 | 0.932 | 0.426 |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.12: New York Parameter Estimates Correcting for Endogenous Prices

| | yellow | white | Russet | fingerling | red | Idaho | creamer |
|---|---|---|---|---|---|---|---|
| $\ln(P_{yellow})$ | -0.041** | 0.016* | 0.023 | -0.001 | 0.060* | -0.062** | -0.001 |
| | (0.014) | (0.007) | (0.018) | (0.001) | (0.029) | (0.015) | (0.007) |
| $\ln(P_{white})$ | 0.016* | -0.091** | -0.004 | 0.000 | 0.028 | 0.038** | 0.016** |
| | (0.007) | (0.012) | (0.015) | (0.001) | (0.022) | (0.009) | (0.005) |
| $\ln(P_{Russet})$ | 0.023 | -0.004 | -0.113* | -0.001 | 0.032 | 0.049 | 0.006 |
| | (0.018) | (0.015) | (0.049) | (0.002) | (0.059) | (0.027) | (0.012) |
| $\ln(P_{fingerling})$ | -0.001 | -0.001 | -0.001 | -0.001 | 0.001 | 0.001 | 0.000 |
| | (0.001) | (0.001) | (0.002) | (0.001) | (0.002) | (0.002) | (0.001) |
| $\ln(P_{red})$ | 0.060* | 0.028 | 0.032 | 0.001 | -0.132 | 0.039 | -0.007 |
| | (0.029) | (0.022) | (0.059) | (0.002) | (0.097) | (0.040) | (0.017) |
| $\ln(P_{Idaho})$ | -0.062** | 0.038** | 0.049 | 0.001 | 0.039 | -0.086* | -0.001 |
| | (0.015) | (0.009) | (0.027) | (0.002) | (0.040) | (0.036) | (0.012) |
| $\ln(P_{creamer})$ | -0.001 | 0.016** | 0.006 | 0.001 | -0.007 | -0.001 | -0.017** |
| | (0.007) | (0.005) | (0.012) | (0.001) | (0.017) | (0.012) | (0.008) |
| $\ln(P_{organic})$ | 0.003 | -0.002 | 0.008 | 0.001 | -0.020* | 0.022** | 0.004 |
| | (0.003) | (0.002) | (0.005) | (0.001) | (0.008) | (0.007) | (0.003) |
| ln(X/P) | 0.035** | -0.001 | -0.042* | -0.001 | 0.022 | -0.005 | -0.006 |
| | (0.009) | (0.012) | (0.020) | (0.001) | (0.029) | (0.012) | (0.006) |
| holiday | 0.002 | -0.001 | -0.010 | 0.001 | 0.010 | -0.004 | 0.003 |
| | (0.004) | (0.005) | (0.008) | (0.000) | (0.012) | (0.005) | (0.002) |
| trend | 0.040** | -0.003 | 0.025 | 0.001 | -0.037 | -0.038** | 0.017** |
| | (0.007) | (0.009) | (0.014) | (0.001) | (0.021) | (0.011) | (0.005) |
| $\ln(P_{rice})$ | -0.026 | 0.059** | 0.097* | -0.001 | -0.056 | -0.030 | -0.033** |
| | (0.017) | (0.022) | (0.039) | (0.002) | (0.054) | (0.023) | (0.012) |
| $\ln(P_{pasta})$ | -0.041* | -0.029 | -0.096* | -0.001 | 0.104 | 0.046 | 0.005 |
| | (0.020) | (0.028) | (0.042) | (0.002) | (0.062) | (0.025) | (0.011) |
| $w_{t-1}$ | 0.314** | 0.297** | 0.325** | 0.445** | 0.317** | 0.300** | 0.397** |
| | (0.034) | (0.033) | (0.031) | (0.076) | (0.032) | (0.037) | (0.037) |
| Constant | -0.474** | 0.065 | 0.860** | 0.007 | -0.167 | 0.207 | 0.136 |
| | (0.134) | (0.174) | (0.293) | (0.011) | (0.423) | (0.177) | (0.084) |
| $R^2$ | 0.419 | 0.699 | 0.477 | 0.376 | 0.201 | 0.772 | 0.628 |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.13: New York Parameter Estimates Without Correcting for Endogenous Prices

| | yellow | white | Russet | fingerling | red | Idaho | creamer |
|---|---|---|---|---|---|---|---|
| $\ln(P_{yellow})$ | -0.029** | 0.021** | 0.017* | 0.001 | 0.024 | -0.037** | 0.001 |
| | (0.011) | (0.005) | (0.008) | (0.001) | (0.016) | (0.010) | (0.005) |
| $\ln(P_{white})$ | 0.021** | -0.078** | 0.022** | -0.001 | 0.006 | 0.025** | 0.004 |
| | (0.005) | (0.007) | (0.008) | (0.000) | (0.012) | (0.006) | (0.003) |
| $\ln(P_{Russet})$ | 0.017* | 0.022** | -0.127** | -0.001 | 0.053* | 0.030** | 0.002 |
| | (0.008) | (0.008) | (0.017) | (0.001) | (0.023) | (0.010) | (0.004) |
| $\ln(P_{fingerling})$ | 0.001 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | 0.001 |
| | (0.001) | (0.000) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| $\ln(P_{red})$ | 0.024 | 0.006 | 0.053* | -0.001 | -0.112** | 0.046* | -0.008 |
| | (0.016) | (0.012) | (0.023) | (0.001) | (0.042) | (0.020) | (0.008) |
| $\ln(P_{Idaho})$ | -0.037** | 0.025** | 0.030** | -0.001 | 0.046* | -0.079** | 0.007 |
| | (0.010) | (0.006) | (0.010) | (0.001) | (0.020) | (0.018) | (0.007) |
| $\ln(P_{creamer})$ | 0.001 | 0.004 | 0.002 | 0.001 | -0.008 | 0.007 | -0.013 |
| | (0.005) | (0.003) | (0.004) | (0.001) | (0.008) | (0.007) | (0.007) |
| $\ln(P_{organic})$ | 0.003 | -0.001 | 0.003 | 0.001 | -0.009** | 0.008** | 0.006** |
| | (0.002) | (0.001) | (0.002) | (0.001) | (0.003) | (0.003) | (0.002) |
| ln(X/P) | 0.037** | 0.012 | -0.030* | -0.001 | 0.009 | -0.011 | -0.014** |
| | (0.007) | (0.010) | (0.014) | (0.001) | (0.021) | (0.008) | (0.004) |
| holiday | 0.003 | -0.005 | -0.013 | 0.001 | 0.011 | -0.001 | 0.006** |
| | (0.003) | (0.005) | (0.007) | (0.000) | (0.010) | (0.004) | (0.002) |
| trend | 0.033** | 0.003 | 0.032* | 0.001 | -0.036 | -0.041** | 0.011** |
| | (0.006) | (0.009) | (0.012) | (0.001) | (0.019) | (0.008) | (0.004) |
| $\ln(P_{rice})$ | -0.022 | 0.034 | 0.083** | -0.001 | -0.045 | -0.022 | -0.023* |
| | (0.015) | (0.021) | (0.030) | (0.001) | (0.045) | (0.018) | (0.009) |
| $\ln(P_{pasta})$ | -0.032 | -0.026 | -0.102* | -0.001 | 0.096 | 0.048* | 0.009 |
| | (0.019) | (0.027) | (0.040) | (0.001) | (0.059) | (0.023) | (0.010) |
| $w_{t-1}$ | 0.373** | 0.351** | 0.380** | 0.464** | 0.374** | 0.369** | 0.456** |
| | (0.029) | (0.028) | (0.027) | (0.072) | (0.027) | (0.029) | (0.030) |
| Constant | -0.499** | -0.123 | 0.661** | 0.004 | 0.015 | 0.272* | 0.240** |
| | (0.102) | (0.145) | (0.201) | (0.008) | (0.308) | (0.123) | (0.060) |
| $R^2$ | 0.447 | 0.699 | 0.481 | 0.375 | 0.194 | 0.783 | 0.671 |

*: p<0.05; **: p<0.01, standard error in parentheses

### *3.4.1 Trend Variable*

The trend variable included in each system of equations was used to estimate and explain changes in the expenditure share over the duration of the data collection period. The trend variable was defined as *t/T*, where *t* = observation 0 to *T* (Moschini and Meilke, 1989; Richards, Kagan and Gao, 1997; Chang et al., 2011). The estimated coefficients for the trend variables are shown in tables 3.4 through 3.13. For ease of comparison, tables 3.4, 3.6, 3.8, 3.10, and 3.12 show the parameter estimates after correcting for endogeneity, while the remaining tables show estimates without this correction.

The trend variable used in each system of equations was not found to be significant for all equations, and did not have a consistent sign across all cities for a given variety. However, the trend variable, when significant at least at the 5% level, was found to more often have a positive coefficient for specialty potato varieties, while well-established varieties more often had a negative coefficient. The only specialty variety with a negative coefficient on the trend variable was organic potatoes in the Dallas and New York systems. The yellow potato variety was found to have a positive trend variable coefficient at the 1% level of significance in four of the five systems: Atlanta, Chicago, Los Angeles, and New York. The trend variable was also found to be positive for the creamer potato variety in Atlanta, Dallas, and New York at the 5%, 1% and 1% level of significance, respectively. Fingerlings in the Atlanta system also had a positive coefficient for the trend variable at the 5% level of significance.

Comparatively, the trend variable, when significant at the 5% level, more often had a negative coefficient than positive for well-established potato varieties. White potatoes had a negative trend variable coefficient in two of the five systems (Chicago and Los Angeles), while red potatoes had a negative trend for two of the five systems (Chicago and Dallas) at the 1%

level of significance. Idaho potatoes had a negative trend variable coefficient in the Chicago and New York systems at the 1% level of significance. The exception to the well-established potato varieties was Russet potatoes, which had a negative trend coefficient in Los Angeles (at the 10% level of significance), but a positive coefficient in Chicago and New York (1% and 10% significance, respectively).

The interpretation of a significant trend variable is how the expenditure share changes linearly with time (Richards, Kagan, and Goa, 1997). Generally, the results suggest that the expenditure share for specialty potatoes increased linearly with time, while well-established varieties decrease linearly with time when significant (the exception being organic and Russet potatoes). However, this general interpretation of the trend variable should be tempered given be the fact that a great deal of heterogeneity across the five cities in terms of significance and sign is observed. Moreover, these results provide evidence that significant differences exist in potato consumption across the five cities over time.

*3.4.2 Holiday Variable*

The holiday explanatory variable was intended to estimate changes in expenditure share during the weeks immediately prior to and containing Easter, the $4^{th}$ of July, Thanksgiving, and Christmas. However, the results from this study surprisingly found few significant holiday effects on potato consumption. Fingerling and red potatoes were the only varieties that had significant increases in consumption during the weeks containing these holidays among the five cities. The estimated coefficient for the holiday variable was found to be positive for the red potato equations in three of five systems: Atlanta, Chicago, and Dallas as the 5%, 5% and 1% level of significance. The coefficient for the holiday variable in fingerling equation was found to be significant in only two of the five equations: Dallas (10% significance) and Los Angeles (1% significance). Meanwhile, white and organic potatoes were found to have negative holiday coefficients in one and three systems, respectively. The coefficient on the holiday variable was found to be negative for the organic equation in Dallas, Los Angeles, and New York at the 10%, 1% and 1% level of significance. The coefficient on the holiday variable was also found to be negative for white potatoes in Atlanta at the 10% level of significance.

These results were surprising given the observed changes in weekly pounds purchased during the winter months and proximity to major holidays (as described in section 2.5). Other studies (e.g., Bond and Richards, 2008) have found significant positive results for holiday variables with respect to potato consumption. Their results, along with the evidence from the relative search frequency from Google Trends suggest that an increase in consumption during major American holidays is likely (Google Inc., 2012). Other specifications of the holiday dummy variable were tried in the model development process for this paper, including dummying a different number of weeks before and after the holiday. However, none of the results found significantly different results than what is presented here. There are several possible explanations for the failure to identify many significant holiday effects. First, a stock-up effect could have occurred where consumers purchased large quantities of potatoes many weeks prior to a holiday. This possibility contrasts with the model specification use in this paper, where the holiday dummy variable equaled one during the week of and prior to a major holiday, zero otherwise. The second explanation is that the variable was incorrectly specified to include all four major holidays combined (as was done in Chang et al., 2011). Instead, it is possible the four holidays should have been modeled with four dummy variables (one for each holiday) as was done in Bond and Richards (2008).

### *3.4.3 Prices of Rice and Pasta*

The logged price of rice and pasta are intended to explain the change in expenditure share conditional on changes in these price variables. One interpretation of the estimated coefficients on the logged prices of rice and pasta represents a $10^2$ times effect on the $i^{th}$ expenditure share conditional on a 1% increase in the price of these goods (interpretation adapted from Deaton and Muellbauer, 1980). However, another way to interpret the coefficient on these variables is based on their sign (positive or negative). It was found that the estimated coefficient on the price of rice had a positive relationship on the expenditure share for all potato varieties at the 1% level of significance. This means that as the price of rice increases, the expenditure share of Russets will also increase. The price of rice was found to generally have a negative relationship with the expenditure share of specialty potatoes within the system of equations. The price of pasta tended to have a negative relationship with Russet potatoes, and was significant in three of the five systems of equations at the 1% level of significance.

## 3.5 Elasticity Estimates

Following the recommendations from Green and Alston (1990), the uncompensated own- and cross price elasticities for the eight potato varieties are calculated using equation (9) from section 2.2. The expenditure elasticities are calculated from equation (11) in the same section of this paper. The uncompensated price elasticities as well as the expenditure elasticities are calculated using the parameter estimates from the linear approximate almost ideal demand system estimates presented in section 3.4. For the reader's convenience, the STATA command that was used to recover the elasticity estimates is provided in the Appendix F of this paper.

The price elasticity estimates are presented in two ways in the following subsections. In subsection 3.5.1, the own- and cross-price elasticity matrices for each of the five cities are presented in their entirety. In this subsection, the own- and cross- price elasticity matrices are presented with and without controlling for endogenous prices. In subsection 3.5.2, the own-price elasticities are presented for ease of comparison. Subsection 3.5.2 also presents the estimated expenditure elasticities from each of the five systems. Both the own-prices elasticity estimates and the expenditure elasticity estimates in this section are presented with and without controlling for endogenous prices.

### *3.5.1 Price Elasticity Matrices*

This section presents the estimated own and cross-price elasticities for the eight potato varieties used in the system of demand equations. Each city has two own- and cross-price elasticity matrices presented: one correcting for endogeneity that was estimated using Hausman and Taylor's (1981) instrumental variable method in an iterative three stage least squares framework, and one without correcting for endogeneity using an iterative seemingly unrelated regression framework. The price elasticity matrices are presented in tables 3.14 through 3.23. The estimated own and cross-price elasticities are shown in bold with p-values below in parenthesis.

Table 3.14: Atlanta Uncompensated Price Elasticities Correcting for Endogeneity

| | $P_{yellow}$ | $P_{white}$ | $P_{Russet}$ | $P_{fingerling}$ | $P_{red}$ | $P_{Idaho}$ | $P_{creamer}$ | $P_{organic}$ |
|---|---|---|---|---|---|---|---|---|
| yellow | -1.845** | 0.024 | 0.054 | -0.005 | 0.140 | 0.263 | 0.121 | -0.074 |
| | (0.078) | (0.070) | (0.114) | (0.005) | (0.090) | (0.135) | (0.054) | (0.057) |
| white | 0.068 | -2.056** | -0.044 | 0.012 | 0.413** | 0.601* | 0.025 | 0.050 |
| | (0.095) | (0.189) | (0.218) | (0.007) | (0.147) | (0.260) | (0.083) | (0.100) |
| Russet | 0.038 | -0.018 | -0.937** | 0.002 | 0.056 | -0.268* | 0.011 | 0.049 |
| | (0.037) | (0.052) | (0.119) | (0.003) | (0.055) | (0.130) | (0.034) | (0.045) |
| fingerling | -0.134 | 0.304 | 0.346 | -1.445** | -0.190 | 0.330 | -0.134 | 0.038 |
| | (0.168) | (0.171) | (0.323) | (0.151) | (0.322) | (0.359) | (0.241) | (0.183) |
| red | 0.147* | 0.223** | 0.240* | -0.003 | -1.603** | 0.121 | 0.115 | 0.012 |
| | (0.060) | (0.073) | (0.116) | (0.006) | (0.141) | (0.144) | (0.063) | (0.060) |
| Idaho | 0.119** | 0.139** | -0.231* | 0.003 | 0.036 | -0.924** | -0.007 | -0.017 |
| | (0.040) | (0.053) | (0.108) | (0.003) | (0.064) | (0.160) | (0.036) | (0.046) |
| creamer | 0.189** | 0.027 | 0.117 | -0.005 | 0.189 | -0.020 | -1.310** | -0.044 |
| | (0.064) | (0.073) | (0.125) | (0.008) | (0.111) | (0.142) | (0.106) | (0.064) |
| organic | 0.223 | 0.492 | 0.845 | -0.001 | -0.208 | -0.919 | -0.251 | -3.618** |
| | (0.461) | (0.553) | (1.036) | (0.042) | (0.676) | (1.178) | (0.413) | (0.591) |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.15: Atlanta Uncompensated Price Elasticities Without Correcting for Endogeneity

| | $P_{yellow}$ | $P_{white}$ | $P_{Russet}$ | $P_{fingerling}$ | $P_{red}$ | $P_{Idaho}$ | $P_{creamer}$ | $P_{organic}$ |
|---|---|---|---|---|---|---|---|---|
| yellow | -1.780** | 0.046 | 0.002 | -0.003 | 0.102 | 0.231** | 0.109 | -0.038 |
| | (0.073) | (0.066) | (0.069) | (0.005) | (0.061) | (0.086) | (0.051) | (0.035) |
| white | 0.084 | -2.136** | 0.068 | 0.013* | 0.486** | 0.332 | -0.013 | 0.084 |
| | (0.089) | (0.176) | (0.151) | (0.006) | (0.112) | (0.187) | (0.077) | (0.072) |
| Russet | 0.037 | 0.024 | -1.077** | 0.002 | 0.037 | -0.032 | 0.020 | 0.059** |
| | (0.023) | (0.035) | (0.068) | (0.001) | (0.030) | (0.079) | (0.019) | (0.021) |
| fingerling | -0.045 | 0.361* | 0.331* | -1.443** | 0.061 | 0.120 | -0.054 | -0.083 |
| | (0.156) | (0.154) | (0.146) | (0.135) | (0.156) | (0.184) | (0.212) | (0.079) |
| red | 0.125** | 0.272** | 0.156** | 0.001 | -1.834** | 0.330** | 0.159** | 0.066 |
| | (0.041) | (0.055) | (0.059) | (0.003) | (0.065) | (0.073) | (0.036) | (0.029) |
| Idaho | 0.095** | 0.077* | -0.074 | 0.001 | 0.103** | -1.260** | 0.009 | 0.000 |
| | (0.027) | (0.038) | (0.066) | (0.002) | (0.034) | (0.100) | (0.023) | (0.024) |
| creamer | 0.174** | 0.003 | 0.110 | -0.002 | 0.265** | 0.093 | -1.454** | -0.050 |
| | (0.060) | (0.067) | (0.066) | (0.007) | (0.063) | (0.085) | (0.093) | (0.034) |
| organic | 0.258 | 0.436 | 0.696 | -0.027 | 0.506 | -0.117 | -0.382 | -4.100** |
| | (0.317) | (0.425) | (0.572) | (0.018) | (0.363) | (0.702) | (0.236) | (0.351) |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.16: Chicago Uncompensated Price Elasticities Correcting for Endogeneity

| | $P_{yellow}$ | $P_{white}$ | $P_{Russet}$ | $P_{fingerling}$ | $P_{red}$ | $P_{Idaho}$ | $P_{creamer}$ | $P_{organic}$ |
|---|---|---|---|---|---|---|---|---|
| yellow | -1.583** | 0.077 | 0.321** | 0.005 | -0.162 | 0.030 | 0.298** | -0.037 |
| | (0.097) | (0.103) | (0.084) | (0.007) | (0.128) | (0.102) | (0.095) | (0.037) |
| white | 0.146 | -1.203** | 0.226* | -0.012 | 0.468** | 0.051 | -0.160 | 0.013 |
| | (0.099) | (0.191) | (0.093) | (0.014) | (0.161) | (0.113) | (0.132) | (0.057) |
| Russet | 0.117** | 0.014 | -1.270** | -0.001 | 0.057 | 0.025 | 0.091** | -0.009 |
| | (0.029) | (0.033) | (0.055) | (0.002) | (0.048) | (0.047) | (0.032) | (0.011) |
| fingerling | 0.175 | -0.430 | 0.001 | -1.405** | 0.065 | 0.434 | 0.670* | -0.280 |
| | (0.228) | (0.454) | (0.183) | (0.221) | (0.429) | (0.229) | (0.311) | (0.297) |
| red | -0.111 | 0.204* | 0.035 | 0.000 | -1.256** | -0.095 | -0.040 | 0.104* |
| | (0.080) | (0.102) | (0.086) | (0.009) | (0.173) | (0.108) | (0.105) | (0.045) |
| Idaho | 0.013 | -0.032 | -0.008 | 0.016 | -0.225 | -1.116** | 0.089 | 0.004 |
| | (0.127) | (0.147) | (0.167) | (0.009) | (0.216) | (0.280) | (0.146) | (0.047) |
| creamer | 0.539** | -0.429 | 0.389 | 0.040* | -0.164 | 0.125 | -1.717** | -0.124 |
| | (0.183) | (0.262) | (0.181) | (0.019) | (0.324) | (0.225) | (0.290) | (0.102) |
| organic | 0.025 | -0.237 | 0.139 | -0.047 | 0.566 | 0.264 | 0.063 | -1.401** |
| | (0.251) | (0.415) | (0.207) | (0.074) | (0.538) | (0.263) | (0.370) | (0.317) |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.17: Chicago Uncompensated Price Elasticities Without Correcting for Endogeneity

| | $P_{yellow}$ | $P_{white}$ | $P_{Russet}$ | $P_{fingerling}$ | $P_{red}$ | $P_{Idaho}$ | $P_{creamer}$ | $P_{organic}$ |
|---|---|---|---|---|---|---|---|---|
| yellow | -1.644** | 0.064 | 0.276** | -0.002 | 0.073 | -0.035 | 0.177** | 0.015 |
| | (0.078) | (0.057) | (0.078) | (0.004) | (0.076) | (0.089) | (0.052) | (0.019) |
| white | 0.139** | -1.144** | 0.292** | 0.002 | 0.268** | 0.024 | -0.020 | -0.013 |
| | (0.053) | (0.071) | (0.069) | (0.004) | (0.068) | (0.083) | (0.048) | (0.017) |
| Russet | 0.105** | 0.035 | -1.288** | -0.002 | 0.087* | 0.013 | 0.078** | -0.005 |
| | (0.026) | (0.025) | (0.053) | (0.002) | (0.038) | (0.045) | (0.025) | (0.008) |
| fingerling | -0.011 | 0.032 | -0.086 | -1.596** | 0.287 | 0.391 | 0.270* | -0.070 |
| | (0.124) | (0.126) | (0.136) | (0.145) | (0.170) | (0.176) | (0.108) | (0.107) |
| red | 0.039 | 0.083 | 0.106 | 0.004 | -1.611** | 0.032 | 0.191** | 0.042** |
| | (0.046) | (0.043) | (0.066) | (0.003) | (0.082) | (0.077) | (0.042) | (0.015) |
| Idaho | -0.068 | -0.071 | -0.056 | 0.015* | 0.037 | -1.175** | -0.029 | 0.0836* |
| | (0.109) | (0.107) | (0.157) | (0.007) | (0.155) | (0.253) | (0.106) | (0.033) |
| creamer | 0.293** | -0.168 | 0.272 | 0.014* | 0.539** | -0.062 | -2.335** | -0.015 |
| | (0.098) | (0.097) | (0.140) | (0.007) | (0.132) | (0.165) | (0.128) | (0.031) |
| organic | 0.189 | -0.123 | 0.102 | -0.019 | 0.534** | 0.565** | -0.008 | -1.886** |
| | (0.147) | (0.146) | (0.166) | (0.027) | (0.197) | (0.211) | (0.130) | (0.129) |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.18: Dallas Uncompensated Price Elasticities Correcting for Endogeneity

| | $P_{yellow}$ | $P_{white}$ | $P_{Russet}$ | $P_{fingerling}$ | $P_{red}$ | $P_{Idaho}$ | $P_{creamer}$ | $P_{organic}$ |
|---|---|---|---|---|---|---|---|---|
| yellow | -1.563** | 0.100 | -0.151 | -0.028 | -0.003 | 0.317 | -0.020 | -0.020 |
| | (0.201) | (0.080) | (0.175) | (0.033) | (0.139) | (0.240) | (0.087) | (0.051) |
| white | 0.131 | -0.829** | 0.348** | -0.062** | 0.100 | -0.143 | -0.092 | -0.102** |
| | (0.071) | (0.066) | (0.079) | (0.021) | (0.071) | (0.120) | (0.060) | (0.026) |
| Russet | 0.000 | 0.016 | -1.075** | 0.005 | -0.008 | -0.018 | -0.005 | 0.018** |
| | (0.020) | (0.011) | (0.050) | (0.004) | (0.023) | (0.041) | (0.012) | (0.005) |
| fingerling | -0.281 | -0.755** | 0.558 | -1.739** | 1.049 | 0.451 | 0.368 | -0.601** |
| | (0.352) | (0.244) | (0.375) | (0.150) | (0.339) | (0.555) | (0.289) | (0.126) |
| red | 0.027 | 0.032 | 0.085 | 0.040** | -1.326** | 0.206* | 0.072* | 0.020 |
| | (0.054) | (0.032) | (0.076) | (0.013) | (0.072) | (0.085) | (0.032) | (0.015) |
| Idaho | 0.117 | -0.064 | 0.010 | 0.012 | 0.137* | -1.120** | 0.021 | 0.016 |
| | (0.065) | (0.037) | (0.091) | (0.014) | (0.058) | (0.130) | (0.040) | (0.020) |
| creamer | 0.006 | -0.122 | 0.053 | 0.038 | 0.194* | 0.095 | -1.128** | 0.005 |
| | (0.091) | (0.070) | (0.101) | (0.029) | (0.085) | (0.151) | (0.155) | (0.042) |
| organic | -0.048 | -0.839** | 1.266** | -0.439** | -0.003 | 0.667 | 0.125 | -2.185** |
| | (0.352) | (0.242) | (0.341) | (0.104) | (0.329) | (0.550) | (0.372) | (0.227) |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.19: Dallas Uncompensated Price Elasticities Without Correcting for Endogeneity

| | $P_{yellow}$ | $P_{white}$ | $P_{Russet}$ | $P_{fingerling}$ | $P_{red}$ | $P_{Idaho}$ | $P_{creamer}$ | $P_{organic}$ |
|---|---|---|---|---|---|---|---|---|
| yellow | -1.470** | 0.033 | -0.078 | -0.050* | -0.009 | 0.118 | -0.027 | 0.016 |
| | (0.111) | (0.046) | (0.134) | (0.020) | (0.096) | (0.134) | (0.046) | (0.021) |
| white | 0.0787* | -0.736** | 0.227** | -0.026 | 0.055 | -0.023 | -0.090* | -0.066** |
| | (0.041) | (0.047) | (0.060) | (0.017) | (0.059) | (0.073) | (0.041) | (0.018) |
| Russet | 0.014 | -0.001 | -1.114** | 0.002 | 0.004 | 0.026 | 0.008 | 0.011** |
| | (0.014) | (0.008) | (0.040) | (0.003) | (0.018) | (0.029) | (0.008) | (0.003) |
| fingerling | -0.506* | -0.314 | 0.287 | -1.616** | 0.864** | 0.550 | 0.418 | -0.471** |
| | (0.212) | (0.197) | (0.302) | (0.144) | (0.309) | (0.383) | (0.256) | (0.116) |
| red | 0.030 | 0.008 | 0.121 | 0.032** | -1.344** | 0.235** | 0.069* | 0.005 |
| | (0.037) | (0.027) | (0.064) | (0.012) | (0.066) | (0.065) | (0.028) | (0.012) |
| Idaho | 0.062 | -0.032 | 0.106 | 0.014 | 0.154* | -1.339** | 0.040 | 0.009 |
| | (0.036) | (0.023) | (0.070) | (0.010) | (0.045) | (0.080) | (0.025) | (0.011) |
| creamer | 0.001 | -0.127** | 0.155 | 0.042 | 0.180* | 0.164 | -1.364** | 0.048 |
| | (0.048) | (0.048) | (0.073) | (0.026) | (0.072) | (0.095) | (0.111) | (0.034) |
| organic | 0.152 | -0.553** | 0.829** | -0.361** | -0.173 | 0.459 | 0.597 | -2.297** |
| | (0.188) | (0.182) | (0.261) | (0.097) | (0.286) | (0.356) | (0.311) | (0.202) |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.20: Los Angeles Uncompensated Price Elasticities Correcting for Endogeneity

| | $P_{yellow}$ | $P_{white}$ | $P_{Russet}$ | $P_{fingerling}$ | $P_{red}$ | $P_{Idaho}$ | $P_{creamer}$ | $P_{organic}$ |
|---|---|---|---|---|---|---|---|---|
| yellow | -1.243** | -0.071 | -0.195 | -0.004 | -0.130 | 0.217** | 0.057 | 0.019 |
| | (0.099) | (0.083) | (0.167) | (0.017) | (0.151) | (0.083) | (0.071) | (0.028) |
| white | -0.026 | -1.032** | -0.172 | -0.020 | 0.458** | -0.050 | 0.037 | -0.035 |
| | (0.059) | (0.097) | (0.143) | (0.013) | (0.154) | (0.080) | (0.058) | (0.024) |
| Russet | 0.002 | -0.028 | -1.206** | -0.002 | 0.046 | 0.195** | 0.020 | 0.0136* |
| | (0.013) | (0.017) | (0.056) | (0.003) | (0.039) | (0.028) | (0.014) | (0.007) |
| fingerling | -0.034 | -0.369 | -0.236 | -2.111** | 1.042* | -0.222 | 0.184 | 0.860** |
| | (0.227) | (0.234) | (0.458) | (0.520) | (0.463) | (0.308) | (0.487) | (0.253) |
| red | -0.023 | 0.203** | 0.191 | 0.026* | -1.285** | 0.015 | -0.049 | -0.024 |
| | (0.049) | (0.071) | (0.154) | (0.012) | (0.171) | (0.084) | (0.056) | (0.019) |
| Idaho | 0.086** | -0.053 | 0.723** | -0.008 | -0.025 | -1.982** | 0.006 | 0.007 |
| | (0.031) | (0.042) | (0.127) | (0.009) | (0.096) | (0.107) | (0.036) | (0.023) |
| creamer | 0.086 | 0.056 | 0.308 | 0.016 | -0.163 | 0.061 | -1.207** | -0.052 |
| | (0.080) | (0.093) | (0.199) | (0.042) | (0.196) | (0.111) | (0.149) | (0.052) |
| organic | 0.129 | -0.238 | 0.546 | 0.377** | -0.454 | 0.261 | -0.137 | -1.624** |
| | (0.186) | (0.191) | (0.368) | (0.116) | (0.367) | (0.228) | (0.282) | (0.197) |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.21: Los Angeles Uncompensated Price Elasticities Without Correcting for Endogeneity

| | $P_{yellow}$ | $P_{white}$ | $P_{Russet}$ | $P_{fingerling}$ | $P_{red}$ | $P_{Idaho}$ | $P_{creamer}$ | $P_{organic}$ |
|---|---|---|---|---|---|---|---|---|
| yellow | -1.402** | -0.224** | 0.003 | 0.004 | 0.023 | 0.131* | 0.075 | 0.046* |
| | (0.080) | (0.062) | (0.106) | (0.012) | (0.088) | (0.060) | (0.057) | (0.023) |
| white | -0.136** | -1.147** | 0.076 | -0.014 | 0.478** | -0.088 | 0.028 | -0.043** |
| | (0.044) | (0.076) | (0.101) | (0.007) | (0.092) | (0.058) | (0.040) | (0.015) |
| Russet | 0.018* | 0.002 | -1.237** | 0.001 | 0.059* | 0.184** | 0.012 | 0.006* |
| | (0.008) | (0.011) | (0.040) | (0.001) | (0.025) | (0.020) | (0.009) | (0.003) |
| fingerling | 0.073 | -0.259 | 0.174 | -2.466** | 0.379* | 0.330* | 0.856 | 0.047 |
| | (0.158) | (0.134) | (0.204) | (0.342) | (0.190) | (0.143) | (0.335) | (0.094) |
| red | 0.025 | 0.212** | 0.229* | 0.009 | -1.476** | 0.095 | -0.061 | 0.004 |
| | (0.029) | (0.042) | (0.102) | (0.005) | (0.098) | (0.057) | (0.031) | (0.009) |
| Idaho | 0.054* | -0.072* | 0.674** | 0.008** | 0.069 | -1.985** | 0.006 | 0.007 |
| | (0.022) | (0.031) | (0.095) | (0.004) | (0.066) | (0.079) | (0.024) | (0.010) |
| creamer | 0.106 | 0.041 | 0.201 | 0.074* | -0.203 | 0.062 | -1.183** | 0.001 |
| | (0.064) | (0.064) | (0.123) | (0.029) | (0.109) | (0.073) | (0.113) | (0.031) |
| organic | 0.219 | -0.341** | 0.308 | 0.015 | 0.059 | 0.155 | 0.047 | -1.595** |
| | (0.143) | (0.136) | (0.208) | (0.044) | (0.188) | (0.137) | (0.172) | (0.095) |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.22: New York Uncompensated Price Elasticities Correcting for Endogeneity

| | $P_{yellow}$ | $P_{white}$ | $P_{Russet}$ | $P_{fingerling}$ | $P_{red}$ | $P_{Idaho}$ | $P_{creamer}$ | $P_{organic}$ |
|---|---|---|---|---|---|---|---|---|
| yellow | -1.424** | 0.119 | 0.107 | -0.002 | 0.514 | -0.644** | -0.031 | 0.025 |
| | (0.131) | (0.066) | (0.163) | (0.009) | (0.284) | (0.143) | (0.066) | (0.030) |
| white | 0.148* | -1.823** | -0.034 | -0.003 | 0.251 | 0.343** | 0.144** | -0.017 |
| | (0.066) | (0.103) | (0.127) | (0.005) | (0.212) | (0.089) | (0.044) | (0.021) |
| Russet | 0.079 | 0.001 | -1.281** | -0.002 | 0.113 | 0.158* | 0.027 | 0.024 |
| | (0.051) | (0.040) | (0.129) | (0.005) | (0.173) | (0.080) | (0.037) | (0.016) |
| fingerling | -0.023 | -0.115 | -0.284 | -1.150** | 0.124 | 0.256 | 0.232 | 0.158 |
| | (0.410) | (0.224) | (0.751) | (0.389) | (1.063) | (0.913) | (0.457) | (0.391) |
| red | 0.314* | 0.137 | 0.132 | 0.001 | -1.739** | 0.196 | -0.050 | -0.111* |
| | (0.152) | (0.113) | (0.292) | (0.013) | (0.544) | (0.221) | (0.095) | (0.044) |
| Idaho | -0.399** | 0.250** | 0.331* | 0.003 | 0.262 | -1.555** | -0.007 | 0.146** |
| | (0.095) | (0.058) | (0.163) | (0.014) | (0.266) | (0.236) | (0.079) | (0.046) |
| creamer | 0.002 | 0.217** | 0.110 | 0.007 | -0.082 | -0.006 | -1.214** | 0.051 |
| | (0.086) | (0.056) | (0.150) | (0.014) | (0.225) | (0.158) | (0.105) | (0.040) |
| organic | -0.064 | -0.220** | 0.556* | -0.007 | -0.106 | 0.406 | 0.206 | -1.740** |
| | (0.137) | (0.083) | (0.252) | (0.046) | (0.386) | (0.307) | (0.141) | (0.144) |

*: p<0.05; **: p<0.01, standard error in parentheses

Table 3.23: New York Uncompensated Price Elasticities Without Correcting for Endogeneity

| | $P_{yellow}$ | $P_{white}$ | $P_{Russet}$ | $P_{fingerling}$ | $P_{red}$ | $P_{Idaho}$ | $P_{creamer}$ | $P_{organic}$ |
|---|---|---|---|---|---|---|---|---|
| yellow | -1.313** | 0.165** | 0.040 | 0.001 | 0.167 | -0.414** | -0.021 | 0.020 |
| | (0.104) | (0.042) | (0.074) | (0.008) | (0.153) | (0.097) | (0.054) | (0.021) |
| white | 0.182** | -1.714** | 0.163* | -0.003 | 0.031 | 0.212** | 0.030 | -0.007 |
| | (0.043) | (0.062) | (0.072) | (0.003) | (0.117) | (0.053) | (0.025) | (0.009) |
| Russet | 0.058 | 0.073** | -1.333** | -0.001 | 0.168* | 0.099** | 0.011 | 0.010* |
| | (0.022) | (0.021) | (0.048) | (0.002) | (0.067) | (0.028) | (0.014) | (0.004) |
| fingerling | 0.080 | -0.102 | -0.124 | -1.125** | -0.208 | -0.171 | 0.371 | 0.388 |
| | (0.344) | (0.137) | (0.248) | (0.358) | (0.511) | (0.500) | (0.420) | (0.350) |
| red | 0.127 | 0.025 | 0.274* | -0.003 | -1.620** | 0.244* | -0.048 | -0.048** |
| | (0.085) | (0.063) | (0.117) | (0.006) | (0.237) | (0.109) | (0.048) | (0.017) |
| Idaho | -0.237** | 0.172** | 0.222** | -0.003 | 0.314* | -1.504** | 0.052 | 0.053** |
| | (0.064) | (0.035) | (0.060) | (0.007) | (0.129) | (0.117) | (0.050) | (0.019) |
| creamer | 0.027 | 0.075* | 0.087 | 0.011 | -0.073 | 0.123 | -1.153** | 0.086** |
| | (0.070) | (0.032) | (0.056) | (0.013) | (0.111) | (0.099) | (0.091) | (0.031) |
| organic | 0.052 | -0.072 | 0.178* | 0.019 | -0.303 | 0.344* | 0.343** | -1.494** |
| | (0.102) | (0.044) | (0.077) | (0.041) | (0.163) | (0.154) | (0.115) | (0.113) |

*: p<0.05; **: p<0.01, standard error in parentheses

The cross-price elasticities off the diagonal of each matrix reveal a number of complementary and substitute relationships between potato varieties. However, it first should be noted that it is difficult to find consistent patterns of significant pricing relationships that are common between cities.  What can be said is that most of the significant cross-price elasticities between varieties indicate substitutes. This is especially true for potato varieties with similar physical and cooking characteristics. For example, Russets, yellow, and red potatoes are found to be substitutes in most systems. It was also commonly found that Idaho and Russet potatoes are substitutes. This result was not surprising since most Idaho potatoes are assumed to be Russet potatoes, as described in subsection 2.4.1 of this paper.

### *3.5.2 Own-Price and Expenditure Elasticity Matrices*

This section presents the own-price elasticity estimates as well as the expenditure elasticities estimates. The estimated elasticities are presented with and without correcting for endogeneity. The own-price elasticities are presented again for convenience, and for a more in depth discussion than what was presented in subsection 3.5.1. The own-price elasticities are presented in Tables 3.24 and 3.25, while expenditure elasticities are presented in Tables 3.26 and 3.27.

Table 3.24: Uncompensated Own-Price Elasticities Correcting for Endogeneity

| | Atlanta | Chicago | Dallas | Los Angeles | New York |
|---|---|---|---|---|---|
| yellow | -1.845 | -1.583 | -1.563 | -1.243 | -1.424 |
| | (0.078) | (0.097) | (0.201) | (0.099) | (0.131) |
| white | -2.056 | -1.225 | -0.829 | -1.032 | -1.823 |
| | (0.189) | (0.191) | (0.066) | (0.097) | (0.103) |
| Russet | -0.937 | -1.271 | -1.075 | -1.206 | -1.281 |
| | (0.119) | (0.055) | (0.050) | (0.056) | (0.129) |
| fingerling | -1.445 | -1.409 | -1.739 | -2.111 | -1.150 |
| | (0.151) | (0.221) | (0.150) | (0.520) | (0.389) |
| red | -1.603 | -1.257 | -1.326 | -1.285 | -1.739 |
| | (0.141) | (0.173) | (0.072) | (0.171) | (0.544) |
| Idaho | -0.924 | -1.102 | -1.200 | -1.982 | -1.555 |
| | (0.160) | (0.280) | (0.130) | (0.107) | (0.236) |
| creamer | -1.310 | -1.718 | -1.128 | -1.207 | -1.214 |
| | (0.106) | (0.290) | (0.155) | (0.149) | (0.105) |
| organic | -3.618 | -1.402 | -2.185 | -1.624 | -1.740 |
| | (0.591) | (0.317) | (0.227) | (0.197) | (0.144) |

all estimates significant at p<0.01, standard error in parentheses

Table 3.25: Uncompensated Own-Price Elasticities Without Correcting for Endogeneity

| | Atlanta | Chicago | Dallas | Los Angeles | New York |
|---|---|---|---|---|---|
| yellow | -1.780 | -1.644 | -1.470 | -1.402 | -1.313 |
| | (0.073) | (0.078) | (0.111) | (0.080) | (0.104) |
| white | -2.136 | -1.144 | -0.736 | -1.147 | -1.714 |
| | (0.176) | (0.071) | (0.047) | (0.076) | (0.062) |
| Russet | -1.077 | -1.288 | -1.114 | -1.237 | -1.333 |
| | (0.068) | (0.053) | (0.040) | (0.040) | (0.048) |
| fingerling | -1.443 | -1.596 | -1.616 | -2.466 | -1.125 |
| | (0.135) | (0.145) | (0.144) | (0.342) | (0.358) |
| red | -1.834 | -1.611 | -1.344 | -1.476 | -1.620 |
| | (0.065) | (0.082) | (0.066) | (0.098) | (0.237) |
| Idaho | -1.260 | -1.175 | -1.339 | -1.985 | -1.504 |
| | (0.100) | (0.253) | (0.080) | (0.079) | (0.117) |
| creamer | -1.454 | -2.335 | -1.364 | -1.183 | -1.153 |
| | (0.093) | (0.128) | (0.111) | (0.113) | (0.091) |
| organic | -4.100 | -1.886 | -2.297 | -1.595 | -1.494 |
| | (0.351) | (0.129) | (0.202) | (0.095) | (0.113) |

all estimates significant at p<0.01, standard error in parentheses

Table 3.26: Expenditure Elasticities Correcting for Endogeneity

| | Atlanta | Chicago | Dallas | Los Angeles | New York |
|---|---|---|---|---|---|
| yellow | 1.320 | 1.050 | 1.368 | 1.350 | 1.336 |
| | (0.105) | (0.079) | (0.164) | (0.056) | (0.089) |
| white | 0.931 | 0.471 | 0.649 | 0.839 | 0.992 |
| | (0.253) | (0.075) | (0.071) | (0.059) | (0.110) |
| Russet | 1.067 | 0.975 | 1.067 | 0.959 | 0.880 |
| | (0.127) | (0.047) | (0.041) | (0.023) | (0.058) |
| fingerling | 0.886 | 0.770 | 0.949 | 0.887 | 0.803 |
| | (0.225) | (0.142) | (0.338) | (0.133) | (0.340) |
| red | 0.749 | 1.158 | 0.844 | 0.945 | 1.120 |
| | (0.103) | (0.078) | (0.068) | (0.064) | (0.160) |
| Idaho | 0.881 | 1.259 | 0.950 | 1.246 | 0.968 |
| | (0.145) | (0.187) | (0.084) | (0.069) | (0.079) |
| creamer | 0.857 | 1.343 | 0.860 | 0.894 | 0.915 |
| | (0.105) | (0.162) | (0.087) | (0.067) | (0.076) |
| organic | 3.898 | 0.521 | 1.728 | 0.933 | 0.894 |
| | (1.187) | (0.190) | (0.380) | (0.116) | (0.118) |

all estimates significant at p<0.01, standard error in parentheses

Table 3.27: Expenditure Elastcities Without Correcting for Edogeneity

| | Atlanta | Chicago | Dallas | Los Angeles | New York |
|---|---|---|---|---|---|
| yellow | 1.331 | 1.076 | 1.467 | 1.343 | 1.355 |
| | (0.098) | (0.075) | (0.141) | (0.054) | (0.067) |
| white | 1.082 | 0.452 | 0.580 | 0.845 | 1.106 |
| | (0.236) | (0.069) | (0.059) | (0.058) | (0.091) |
| Russet | 0.930 | 0.976 | 1.051 | 0.955 | 0.915 |
| | (0.112) | (0.047) | (0.038) | (0.023) | (0.040) |
| fingerling | 0.753 | 0.783 | 0.787 | 0.864 | 0.891 |
| | (0.202) | (0.122) | (0.294) | (0.103) | (0.237) |
| red | 0.724 | 1.114 | 0.843 | 0.964 | 1.049 |
| | (0.090) | (0.065) | (0.064) | (0.063) | (0.117) |
| Idaho | 1.050 | 1.264 | 0.986 | 1.239 | 0.931 |
| | (0.129) | (0.181) | (0.073) | (0.068) | (0.055) |
| creamer | 0.862 | 1.462 | 0.902 | 0.901 | 0.817 |
| | (0.095) | (0.142) | (0.070) | (0.066) | (0.054) |
| organic | 2.694 | 0.521 | 1.563 | 0.906 | 0.850 |
| | (1.037) | (0.159) | (0.285) | (0.110) | (0.074) |

all estimates significant at p<0.01, standard error in parentheses

Table 3.24 shows the own-price elasticity for each of the eight varieties after correcting for endogeneity. It should be noted that all own-price elasticities in this table are found to be significant at the 1% level. This metric describes is how a 1% increase in own price will decrease pounds purchased by the corresponding number shown in Table 3.24. For example, a 1% increase in the price of yellow potatoes in Atlanta will decrease pounds purchased by 1.845%. As shown in this table, most of the potato varieties across all five cities are found to be elastic with values less than -1. The three cases where inelastic demand is observed are for Russets and Idaho potatoes in Atlanta, and white potatoes in Dallas. Significant differences in consumer sensitivity to price can be observed between the five cites. For example, the own-price elasticity for yellow potatoes is found to be -1.243 in Los Angeles and -1.845 in Atlanta. Even more striking are the differences in consumer sensitivity to organic potatoes. The own-price elasticity for organic potatoes is found to be -3.618 in Atlanta and -1.402 in Chicago.

Comparing the estimated own-price elasticities reveals that generally, consumers are more price sensitive to the specialty potatoes relative to the Russet potatoes. In Atlanta, Chicago, Dallas, and Los Angeles, the own-price elasticities for yellow, fingerling, creamer, and organic potatoes are relatively more elasticity compared to Russets. However, in Los Angeles, the own-price elasticity for creamer potatoes is only marginally more elastic compared to Russets; -1.207 for creamers compared to -1.206 for Russets. In New York, consumers have different price sensitivity towards specialty potatoes compared to the well-established Russet potato. Here, yellow and organic potatoes are found to be more price sensitive relative to Russet potatoes, while the opposite is found to be true with fingerling and creamers. With an own-price elasticity of -1.281, Russets are found to be relative more elastic than fingerling potatoes (-1.150) and creamer potatoes (-1.214).  It is also interesting to note that prior to correcting for endogeneity, Russet potatoes are found to be relatively more elastic than yellow potatoes (as shown in Table 3.25).

Comparing Table 3.24 and Table 3.25 reveals that the estimated own-price elasticities did not radically change upon correcting for endogeneity. Generally, correcting for endogeneity tended to produce relatively more inelastic own-price elasticities compared to the results without correcting for endogeneity. Idaho and Russet own-price elasticities found in the Atlanta system are the only elasticities to switch from elastic to inelastic demand upon correction of endogeneity. Organics in Atlanta are highly elastic (-4.100), and became relatively more inelastic upon correcting for endogeneity (-3.618).

Table 3.28 summarizes the own-price elasticities estimated from Bond and Richards (2008), Hsieh, Mitchell, and Stiegert (2009), and Zhang et al (2006). The first two studies shown in the table found similar elasticities for white and red potatoes, but far different elasticity estimates for Russets. Bond and Richards and Zhang et al. found similar estimates for organic potatoes. Hsieh, Mitchell, and Stiegert found that the own-price elasticity for organic potatoes was not statistically different from zero.

Table 3.28: Own-Price Elasticities From Previous Potato Demand Studies

| *Potato Variety* | Bond and Richards (2008) | Hsieh, Mitchell and Stiegert (2009) | Zhang et al. (2006) |
|---|---|---|---|
| Russet | -0.23* | -1.38** | |
| Red | -0.35* | -0.86** | |
| Creamer | -1.15* | | |
| Organic | -1.27* | -1.36 | -1.11* |
| Yukon | -1.34* | | |
| Yellow | -1.06* | | |
| White | -0.52* | -0.55** | |
| Minor Colored | | -1.62* | |

*: $p<0.05$, **: $p<0.01$

The summary of own-price elasticity results from other potato demand studies, shown in Table 3.28, contrasts with some of the results calculated in this study. For example, Bond and Richards (2008) estimated the own-price elasticities for Russet and red potatoes to be much more inelastic than the results shown in Table 3.24. Hsieh, Mitchell, and Stiegert (2009) found Russets to be slightly more elastic, and red potatoes to be slightly less elastic than the results from this paper. Bond and Richards (2008) found organic, yellow, white, and creamer potatoes to be relatively more inelastic.

Table 3.26 shows the estimated expenditure elasticities for each variety after correcting for endogenous prices. Typically, the expenditure elasticity is used as a proxy for the income elasticity. However, since the empirical model used in this study assumed weak separability from all other goods, the interpretation of the expenditure elasticity as a proxy for income elasticity may not hold. Under the assumption that the expenditure elasticity is a proxy for an income elasticity, this table would indicate that all of the potato varieties are found to be normal goods in each of the five cities (elasticity>0), while some are found to be luxury goods (elasticity>1).

However, an increase in expenditure on potatoes very may well mean that consumers are becoming relatively poorer, and thus substitute away from other goods in favor of increased potato consumption. The econometric model results in this paper cannot discern between the potentially competing causalities driving in the changes in total potato expenditure. Regardless, inferences can still be made about behavior when the total potato expenditure does increase.

All of the estimated expenditure elasticities are found to be positivity and significant at the 1% level. What this metrics describes is how a 1% increase in total potato expenditure will change pounds purchased by the corresponding amount per variety. For example, a 1% increase in expenditure will result in a 1.32% increase in yellow potato pounds purchased in Atlanta as shown in Table 3.26. Comparing the specialty potatoes (yellow, fingerling, creamer, and organic) to the commodity Russet potato reveals interesting consumer behavior. When total potato expenditure increases, quantity demanded for yellow potatoes increases greater than Russet potatoes in all five cities. The opposite was found to be true for fingerling potatoes with respect to Russet potatoes. When total potato expenditure increases, quantity demanded for Russet potatoes increases greater than for fingerling potatoes in all five cities. Also found was mixed responses between cities when comparing creamer and organic potatoes to Russet potatoes. The expenditure elasticity for creamer potatoes and organic potatoes was less than Russets in three cities (Atlanta, Dallas, and Los Angeles) and two cities (Chicago and Los Angeles), respectively. These results indicate that as the total expenditure for potatoes increases, quantity demanded for Russet potatoes will increase greater than creamer and organic potatoes in the respective identified cities.

Comparing Table 3.26 and Table 3.27 reveals that correcting for endogenous prices changed the estimated expenditure elasticities very little. However, in several cases, correcting for endogeneity switched some expenditure elasticities from less than one to greater than on, and vice versa. The expenditure elasticity for potatoes in Atlanta and New York switched from being a greater than one to less than one. The same can be said for the expenditure elasticity for Idaho potatoes in Atlanta. The expenditure elasticity for Russets in Atlanta switched from being a less than one to greater than one upon correcting for endogeneity.

The estimated elasticities shown in Tables 3.24 through 3.27 indicate that significant differences exist for different potato varieties within the potato category. These results indicate that consumer demand for different potato varieties have varying degrees of sensitivity to changes in own-price. It is also interesting to note that all potato varieties were found to be normal goods, while some were found to be luxuries (with an expenditure elasticity >1). Most importantly, Tables 3.24 through 3.27 indicate that consumer behavior and demand towards potato consumption at the varietal level is highly heterogeneous between the five different cities in the United States. Some potato varieties were found to be inelastic with respect to price in one city but then were found to be highly elastic in another (see own-price elasticities for white potatoes in Table 3.24 as an example).

# CHAPTER 4: MARKETING IMPLICATIONS AND SUGGESTIONS FOR COLORADO SPECIALTY POTATOES

As a new product, a significant challenge that faces Colorado specialty potatoes is the limited marketing research available to the industry. Therefore, the goal of the marketing section of this thesis is provide additional information to the Colorado potato industry to improve upon marketing programs of these new cultivars. The marketing chapter of this thesis will first provide a SWOT analysis that will discuss the identified threats, opportunities, weaknesses, and strengths that face the emerging Colorado specialty potato market. The second component to this marketing chapter is to identify target markets by referencing recent research on emerging consumer trends. The third element of this marketing chapter is it present a marketing mix that provides a product description, pricing strategies, promotional suggestions, and placement so that the target market can most easily access the product. The forth element of this chapter is a discussion on the generalization of the marketing recommendations found in this chapter to the Colorado and Front Range markets. The final component is to recommend future considerations based off of the limitations from the work presented in this chapter. It should be noted that the he SWOT analysis and the subsequently discussed marketing mix are focused on the marketing of Colorado specialty potatoes to consumer, as opposed to market intermediaries such as distributors and retailers.

## 4.1 SWOT Analysis – Strengths, Weaknesses, Opportunities, and Threats

The matrix labeled as table 4.1 shows the SWOT (strengths, weaknesses, opportunities, and threats) analysis for Colorado specialty potato varieties. The goal of this analysis is to compile and objectively analyze the internal and external situation that faces the emerging Colorado specialty potato market.

Table 4.1: SWOT Analysis for Colorado Specialty Potatoes

| **Strengths** | **Opportunities** |
|---|---|
| 1. High nutritional content<br>2. Adds variety to a well-established product line<br>3. Colorado-grown product<br>4. Can be differentiated as a high quality, unique, and gourmet product (Olsen et al. 2003) | 1. Growing demand for local food movement<br>2. Increased health awareness of consumers<br>3. Growing demand for distinctive high-quality food experiences ; “foodie” consumers |
| **Weaknesses** | **Threats** |
| 1. Consumers unfamiliar with product<br>2. High sensitivity to changes in price | 1. Competition from Idaho growers (Mitchell, 2012)<br>2. Negative health perception and press of potato consumption<br>3. Inclement weather may damage crop<br>4. Lack of water may inhibit production<br>5. Lack of producer support for consistently supplying specialty products for emerging markets<br>6. Lack of packing house knowledge of consumer demand for specialty potatoes and potential market outlets<br>7. Lack of production contract for specialty potatoes<br>8. Lack of secondary markets for unsold specialty potatoes<br>9. Pest infestation may damage crop |

Four strengths were identified for Colorado specialty potatoes. The first strength Colorado specialty potatoes face is the positive nutritional qualities on a consumer’s health. In terms of additional health benefits, research on Colorado developed cultivars has shown that potatoes with pigmented flesh have significantly higher antioxidant levels relative to non-pigmented flesh varieties (Stushnoff, 2008). The second strength is that specialty potatoes add variety to a product line that is in the mature phase of the product life cycle. Since Russet potatoes make up the bulk fresh potato production in Colorado, the introduction of specialty potatoes can generate interest in a product line due to the newness of the product. The third strength of the specialty potatoes in our study is that they are Colorado-grown and consumers have indicated a preference to purchase products that are identified as being locally-grown. The fourth strength is how, given the added-value nature of the product, Colorado specialty potatoes can offer a unique, high quality, gourmet product that are available in diverse colors, textures, and size (Olsen et al., 2003).

The two weaknesses identified that Colorado specialty potatoes face are consumer unfamiliarity with the new product, and consumers' high sensitivity to price relative to well-established commodity potato varieties. An example of the lack of consumer knowledge about Colorado specialty potatoes is reflected in the results from the experiment with sensory analysis conducted at Colorado State University (Bond et al., 2011). This study found that consumer respondents were least knowledgeable about the nutritional information relative to other attributes of specialty potato varieties. As one of the strengths of specialty potatoes, nutritional quality is not obvious to the health conscious consumer, but with appropriate promotional strategies this information can easily be conveyed to the consumer. The second weakness that Colorado specialty potatoes face is consumers' high sensitivity changes in price relative to well-established potato varieties, such as the Russet. Although the mean price of specialty potatoes can be up to six times more expensive per pound than Russet potatoes, the econometric results from this study show that, generally, specialty potatoes are relatively more elastic than Russet potatoes.  This indicates that optimal promotional activities and pricing strategies may be a challenge to determine.

The opportunities that Colorado specialty potatoes face are three external consumer trends. The first identified external opportunity is the increasing demand for locally grown food. The local food movement has seen significant momentum recently, and has been expected to be one of the top restaurant trends for 2012 (NRA, 2011; Urban, 2011). Growth in the local food movement also is evident by the increase in the number of farmers markets nation-wide (USDA-AMS, 2011). The second identified opportunity is increased health awareness among consumers. A leading health trend that has recently emerged, in part, as a way to manage weight and overall healthiness is the whole food nutrition movement. The food movement is wellness focused; linking diet and overall health as the crux (Hasler and Brown, 2009). Specialty varieties, such as the “Mountain Rose” and “Purple Majesty” developed by the Colorado potato breeding program, contain high levels of antioxidants (Stushnoff et al., 2008), and can possibly be marketed consumers who seek a whole food nutrition diet. The third external opportunity that Colorado specialty potatoes face is the rise of “foodie” consumers who have an interest in distinct high-quality food experiences (Hartman Group, 2006). This group of consumers is willing to indulge in upscale and gourmet foods as part of an overall eating experience beyond the uniformity of conventional foods. Promoted as a unique culinary experience, Colorado specialty potatoes can promote the interesting textures, flavors, colors, and sizes that the emerging “foodie” culture desires.

The SWOT matrix presents nine identified threats that face the emerging Colorado specialty potatoes market. First, competition from Idaho Potato growers is a significant concern. Idaho Potato Commission president and chief executive officer, Frank Muir, has made it clear that the goal is for Idaho to be a one-stop shop for all potatoes, both well-established and specialty varieties (Mitchell, 2012). Recently, specialty potato growers and mainstream potato growers in Idaho have begun to collaborate and leverage their image to promote sales of fingerlings and other specialty varieties. Muir has stated that Idaho specialty potato sales have increased significantly during the past six years, and now account for 5% of all Idaho potato sales. The second identified threat that Colorado specialty potatoes face is the perception of negative health attributes of consumption. This perception was greatly influenced by the low carbohydrate diet movement that began in the early 1990s (Atkins 1992; Nielsen, 2004). A 2011 United States Potato Board survey suggested that since the peak of the low carbohydrate diet movement, American consumers are less frequently citing potatoes as fattening. However, results from a journal article published in the New England Journal of Medicine concluded that the consumption of potatoes was a significant long-term factor in weight gain in men and women (Mozaffarian et al., 2011). Following the publication of this journal article was widely distributed coverage by the popular media on their results (see Cevallos (2011) as an example).

The additional seven threats that this emerging market faces can be generally be divided into two categories. The first category can be considered environmental risks, while the second category deals with production and supply chain issues.  The environmental threats that face the Colorado specialty market include severe weather, drought, and pest infestation. These threats are not exclusive to the Colorado specialty potato market, but should be considered regardless. The product and supply chain concerns that this emerging marketing face is lack of producer support, lack of market outlets, lack of production contracts, and lack of secondary markets for unsold products.

### 4.2 Target Market

The target market for Colorado specialty potatoes consist of three identified segments. The first market segment identified is health conscious consumers. Considering that the national obesity rates, along with the associate health risks, have increased substantially during the previous 25 years (Flegal et al., 2010), it is not surprising that researchers and consumers have sought a response to such trends. A recent health trend that emerged, in part, as a way to manage weight and overall health is the whole food nutrition movement. This movement is wellness focused; linking diet and overall health is the crux for these consumers (Hasler and Brown, 2009). A recent study that reviewed the literature of consumer trends on functional foods (i.e., whole food) overwhelmingly reported that women were much more likely than men to participate in a functional foods diet (Siro et al., 2008). Generally, their review concluded that well-educated and high income consumers were also more likely to participate in a whole food diet. In a recent experimental and sensory analysis study, consumer respondents increased their willingness to pay upon revelation of the nutritional characteristics of the potato varieties (Bond et al., 2011). Their results found that the Purple Majesty potato variety experienced the greatest increase in the respondents' willingness to pay upon knowing the nutritional characteristics among all varieties included in the experiment. Potatoes in general are very nutritious; one medium sized potato with the skin on contains 110 calories, nearly half of the value of vitamin C, and is a good source of fiber (see Appendix G for additional nutritional resources) (USPB, 2012). Specialty varieties, such as the "Mountain Rose" and "Purple Majesty," that contain high levels of antioxidants (Stushnoff et al., 2008) can be marketed to this segment of consumers. Specialty potatoes may be positioned well for the whole food nutrition movement by providing the consumer a highly nutritious product that can be differentiated from well-established commodity potatoes due to the high antioxidant content.

The second market segment that Colorado specialty potatoes can appeal to is the "foodie" consumer. This group has an interest in distinct high-quality food experiences (Hartman Group, 2006). The original usage of the "foodie" was attributed to the book, *The Official Foodie Handbook (Be Modern-Worship Food)* by Levy and Bar (Johnston and Baumann, 2010). Johnston and Baumann explain how foodie consumers see food as a hobby; as a way to be creative and explore the culinary arts. This group of consumers is willing to indulge in upscale and gourmet foods as part of an overall eating experience beyond the uniformity of conventional foods. Research from the Hartman Group has found that a key component of "foodie" culture is the fascination with new and exciting information from food oriented magazines, television shows, websites, and online blogs. The Hartman Group report stated that "foodie" consumers are very diverse in terms of demographic segmentation. Levy and Bar (2010) indicate that in general, "foodies" can be characterized as an ambitious and a well-educated group. Promoted as a unique culinary experience, Colorado specialty potatoes can provide interesting textures, flavors, colors, and sizes that the "foodie" consumers seek.

The growth in the local food movement is the third identified target market for Colorado specialty potatoes. Growth in the local food movement is evident by the increase in the number of farmers' markets nation-wide, which grew 17% from 2010 to 2011 (USDA-AMS, 2011). Additionally, previous research has shown that consumers were willing to pay a higher premium for Colorado-grown potatoes relative to organic and GMO-free potatoes (Loureiro and Hine, 2001). Colorado specialty potatoes can be positioned to take advantage of the local food movement, but in order to do so must clearly communicate to the consumer of this attribute. The

“Colorado Proud” label is an easy way to communicate this message to consumers at the grocery store.

An important component of a marketing strategy is to consider what the target market needs and desires, then appropriately manage how the product being offered meets those needs. With the three target market segments identified as health conscious consumers, “foodies,” and consumers who seek locally grown food, Colorado specialty potatoes have the opportunity to meet the needs of these target markets by providing a unique, nutritional, and locally grown product these consumer groups desire. It should also be mentioned that these consumer groups are not mutually exclusive, and that a great deal of overlap may exist between the three.

## 4.3 Marketing Mix

### *4.3.1 Product*

When considering what Colorado specialty potatoes are as product, it is important to consider three levels of values. First, the core customer value addresses what the customer is actually buying (Kotler and Armstrong, 2007). To understand this value level, it is first important to consider what the target market needs in a product, and then providing the consumer with a way to meet those needs. In the case of Colorado specialty potatoes, the target markets want locally-grown, healthy, unique, and diverse culinary experiences. What Colorado specialty potatoes provides to these consumers are healthy, Colorado-grown, unique cultivars of high quality, which are available in diverse colors, textures, and sizes (Olsen et al., 2003). The second value to consider is the actual product. This is the level where the design of packaging, tuber cleanliness, and branding of Colorado specialty potatoes becomes important. The third value level is the augmented product. Here, the consumers' perception of the value of the specialty product can be enhanced by adding features such as improved nutritional labeling and claims, unique recipe ideas, satisfaction guarantees and convenient packaging.

*4.3.2 Pricing Strategy*

The results from an economic experimental study on specialty potatoes and sensory analysis found that consumer respondents cite price as one of the top two most influential factors in the potato purchase decision (Bond et al., 2011). In this same study, researchers found that all of the value-added specialty potato varieties had a higher average willingness to pay relative to the well-established Russet potatoes. This study also found a slight increase in average willingness to pay upon revelation of the nutritional characteristics of the potato varieties. The specialty variety, Purple Majesty, experienced the greatest increase in the respondents' willingness to pay upon knowing the nutritional characteristics. Other research found a higher willingness to pay for Colorado-grown potatoes relative to organic and GMO-free potatoes (Loureiro and Hine, 2001). The results and conclusions from these studies indicate that specialty potatoes can receive a higher price premium relative to Russets, and can have a higher willingness to pay from consumers if nutritional and locally grow attributes are well promoted.

Suggestions on the pricing strategy for Colorado specialty potatoes can also be guided by the summary statistics and the estimated price elasticities presented in sections 2.5 and 3.5 of this study. However, the specialty potato prices and the sensitivity of consumers to these prices should be taken with a note of caution. First, the data are several years old; the most recent observation in the dataset used in this study was collected in September of 2008. Second, the five cities where the data were collected may not be generalizable to the Colorado consumer market.

Third, the eight potato varieties included in this study may not be generalizable to all specialty varieties grown in Colorado. With these words of caution in mind, the information included in this study on specialty potato prices are, at a minimum, provide a real-world derived frame of reference and offer perspectives on the relative magnitude of price difference across varieties and cities. Tables 5.1 and 5.2 show the mean prices and the estimated own-price elasticities calculated in this study. The own-price elasticity table only shows the estimate results upon correcting for endogeneity. Interested readers are advised to view subsection 3.5.2 for a table of own-price elasticities that are not corrected for endogeneity.

Table 4.2: Mean Weekly Prices ($) by City During Data Collection Period

| | yellow | white | Russet | fingerling | red | Idaho | creamer | organic |
|---|---|---|---|---|---|---|---|---|
| Atlanta | 0.99 | 0.69 | 0.69 | 3.10 | 0.76 | 0.71 | 1.17 | 1.05 |
| Chicago | 0.92 | 0.80 | 0.51 | 2.78 | 0.67 | 0.47 | 1.61 | 0.65 |
| Dallas | 0.78 | 0.95 | 0.54 | 1.75 | 0.83 | 0.69 | 1.68 | 1.04 |
| Los Angeles | 1.16 | 0.89 | 0.54 | 2.89 | 0.83 | 0.48 | 1.96 | 1.03 |
| New York | 1.02 | 0.56 | 0.73 | 3.25 | 0.96 | 0.80 | 1.87 | 1.13 |

Table 4.3: Potato Variety's Own-Price Elasticity by City

| | yellow | white | Russet | fingerling | red | Idaho | creamer | organic |
|---|---|---|---|---|---|---|---|---|
| Atlanta | -1.845 | -2.056 | -0.937 | -1.445 | -1.603 | -0.924 | -1.310 | -3.618 |
| Chicago | -1.583 | -1.225 | -1.271 | -1.409 | -1.257 | -1.102 | -1.718 | -1.402 |
| Dallas | -1.563 | -0.829 | -1.075 | -1.739 | -1.326 | -1.200 | -1.128 | -2.185 |
| Los Angeles | -1.243 | -1.032 | -1.206 | -2.111 | -1.285 | -1.982 | -1.207 | -1.624 |
| New York | -1.424 | -1.823 | -1.281 | -1.150 | -1.739 | -1.555 | -1.214 | -1.740 |

all estimates significant at $p<0.01$

Table 4.2 shows the mean price per pound of the eight potato varieties used in this study per city during 2006 through 2008, while 4.3 shows own-price elasticities. Although not included in the system of demand equations due to lack of observations, purple potatoes have a mean price of $2.16 per pound from 2006 through 2008 across the five cites combined. No absolute conclusions can be made about the own-price elasticity of the purple variety relative to other varieties given the exclusion of purples from the system of demand equations. However, it is reasonable that the own-price elasticity for purple potatoes can be assumed to be in a similar range as the yellow, fingerling, creamer, and organic potato varieties. These varieties each were found to face relatively elastic demand with respect to price.

The estimated results shown in tables 4.2 and 4.3 indicate several important characteristics about the prices of specialty potatoes. First, the yellow, fingerling, creamer, and organic potato varieties each had a higher mean price per pound relative to the well-established Russet, white, and red varieties across all five cities. Fingerling potatoes had the largest mean price premium per pound relative to Russets, with nearly six times the price in several of the cities. Second, nearly all potato varieties in each city were found to face elastic demand with respect to price. The specialty potato varieties were found to be more price sensitive relative to Russets in nearly all cases. The two exceptions were found in the New York; consumers in this city were slightly more sensitive Russets prices than to the prices of fingerlings and creamers. Unexpectedly, the price elasticity for organic potatoes had no definitive trend when comparing across the five cities. For example, Atlanta consumers were much more sensitive to changes in price relative to Chicago consumer with price elasticities roughly -3.6 and -1.4, respectively. Similar observations are made about the differences in the price elasticities of fingerling potatoes between the different cities. Specifically, consumers in New York were found to be the least sensitive to changes in the price of fingerlings relative to the four other cities. In this case, fingerlings in New York had a price elasticity of -1.1, while the other four cities had a range of -1.4 to -2.1.

What these results indicate is that among the cities compared in this study, consumers are relatively more price sensitive to the well-established Russet potato variety. It is also found that the mean price per pound for the specialty varieties were generally greater than well-established varieties during the data collection period. These results, and the results and conclusions from previous studies, can guide the retailer and product promoter in appropriate pricing strategies. When developing a pricing strategy for Colorado specialty potatoes, an additional element to consider is the experiential nature of the product. Since taste has been shown to be the most important potato attribute to consumers (Bond et al., 2011), penetration pricing should be considered to encourage consumers to try the new product in order to gain acceptance. This pricing strategy sets the initial price low to incentivize trial (Kotler and Armstrong, 2007). The goal with this strategy is the maximize consumer trials of the product to develop experience with the product. After a period of time the price can be increased and set to a new pricing strategy. For example, a competitive matching pricing strategy could later be considered for Colorado specialty potatoes. By matching the price of competing specialty potatoes, such as Idaho specialty potatoes, consumer loyalty may be developed by promoting the locally grow attribute over competition with the same price. However, a competitive matching pricing strategy first requires knowledge about the prices of existing competitors. Table 4.4 provides examples of current market prices for potato varieties available (as of May 24, 2012) at King Soopers and Whole Foods Market in Fort Collins, CO. This table highlights the significant differences that exist in per pound pricing between Russets ($0.29 - $0.89) and available specialty varieties (up to $2.66).

| Table 4.4: Observed Potato Varieties and Current Prices* at Whole Foods Market and King Soopers in Fort Collins, CO | | |
|---|---|---|
| **Varieties Available by Store** | **Price per pound ($)** | **Packaging Availability** |
| ***Whole Foods*** | | |
| Organic yellow creamer | 1.99 | 2 lb bags |
| Organic red creamer | 1.99 | 2 lb bags |
| Organic Colorado-grown fingerlings | 1.99 | 1 lb bags |
| Colorado-grown Russet | 1.49 | loose |
| ***King Soopers*** | | |
| Dutch baby | 2.66 | 1.54 lb bags |
| Baby red | 2.66 | 1.5 lb bags |
| "Star Spangled" fingerlings | 1.99 | 2 lb bags |
| Multi-colored fingerlings | 1.75 | 2 lb bags |
| Organic red | 1.66 | 3 lb bags |
| Red | 1.29 | loose |
| Organic Russet | 1.16 - 1.33 | 3 lb bags |
| Yellow | 0.99 | loose |
| Yukon Gold | 0.80 | 5 lb bags |
| Red | 0.80 | 5 lb bags |
| Russets | 0.29 - 0.89 | 5, 8, and 10 lb bags |

*as of May 24, 2012

An additional resource that highlights pricing differences can be found in the USPB's Retail Marketing Toolkit (2001), which is presented in Table 4.5. Although somewhat dated, the pricing options between the different categories of potatoes provides important complementary information to the observed prices shown in Table 4.4.

| Table 4.5: Pricing Options from the USPB Retail Marketing Toolkit (2001) | |
|---|---|
| **Potato Category** | **Price per pound ($)** |
| Specialty | 0.85+ |
| Premium | 0.70 - 0.80 |
| Mainstream | 0.45 - 0.65 |
| Bargain | 0.20 - 0.30 |

The observed per pound price of Russet potatoes at King Soopers was found to be $0.29 to $0.89, which roughly fits within the range of bargain and mainstream potato category pricing provided by the USPB. Table 4.5 indicates that specialty potatoes can be priced with at least a $0.20 to $0.40 premium above the mainstream potato category, and $0.55 to $0.65 above the bargain category. The observed pricing of specialty potatoes at Whole Foods and King Soopers tended to well exceed the USPB's minimum recommendation of $0.85 per pound.

A range of example pricing strategies of select Colorado specialty potatoes is presented in Table 4.6. The range of prices was developed by considering the mean price from the data used in this paper, the observed current potato prices in Fort Collins, CO, and the pricing strategies recommended by the USPB.

Table 4.6: Example Competitive Matching Pricing Strategy for Colorado Specialty

| **Variety** | **Price per pound ($)** | **Percent Premium over Russet Potatoes** |
|---|---|---|
| Purple Majesty | 1.99 - 2.49 | > 60% |
| Lady Pinto | 1.99 - 2.49 | > 60% |
| Mountain Rose | 1.99 - 2.49 | > 60% |
| Sangre | 1.29 - 1.99 | > 10% |
| Aspen | 0.89 - 1.49 | > 5% |

Table 4.6 shows two important features to the pricing strategy for each Colorado specialty cultivar. First, the range of prices presented in the second column of Table 4.6 was designed as a competitive matching pricing strategy. The third column of Table 4.6 shows how the premium on price per pound for specialty varieties can be identified given the price of Russet potatoes. This general "percent premium" guideline was developed based on the results from the sensory analysis results from Bond et al. (2011).

The upper range of prices for the Purple Majesty, Lady Pinto, and Mountain Rose cultivars were set by considering the prices of similar specialty cultivars from King Soopers (Dutch baby, baby red, “Star Spangeled” fingerlings, and multi-colored fingerlings). The lower range for these cultivars was set to match the observed prices of the varieties found at Whole Foods. This is to show that changes in pricing strategy can be made in order match the competition depending upon which store the cultivars are placed in. Shown in the third column of Table 4.6, the results from Bond et al. (2011) found that consumers were willing to big roughly 60% higher on the Purple Majesty and Lady Pinto varieties above what was bid for the standard Russets. It is assumed that the Mountain Rose cultivar can receive a similar percent markup relative to standard Russets.

The two other cultivars in Table 4.6, Aspen and Sangre, are shown with a slightly lower range of prices. Aspen is a new Russet cultivar, and likely will manage to receive a slightly higher price premium over the standard Russet currently available. The upper range for Aspen was determined by the current price per pound for Colorado-grown Russets at Whole Foods. The lower price for Aspen was set equal to the observed high price per pound for Russets at King Soopers. The results from Bond et al. (2011) showed that in an experimental setting, consumers were willing to bid only slightly more per pound for Aspen above what their bid was for standard Russets. This is indicative by the corresponding price premium over Russets (>5%) show in the third column of Table 4.6. Although Bond et al. (2011) had no results on Sangre (a red skinned cultivar); it was assumed that the pricing strategy range would match the current price per pound of red potatoes at King Soopers ($1.29) and organic red potatoes at Whole Foods ($1.99).

*4.3.3 Place*

The Colorado Potato Administrative Committee is primarily interested in distributing and selling specialty potatoes in the Colorado market. This is due to the high relative cost of transportation of specialty potatoes compared to the well-established varieties. The Colorado Potato Administrative Committee is also primarily interested in offering specialty potatoes in mainstream market stores (King Soopers, Safeway), and not just in natural and health food stores, such as Whole Foods or Vitamin Cottage. While growth in both the production and sales of specialty potatoes is viewed as a positive, getting product into supermarkets is especially appealing in light of the potential volume of demand for product, the relatively lower transactions costs associated with transporting to fewer locations and working with fewer buyers, as well as the relative consistency of demand for product and exposure to members or each identified target market. Potato placement within the grocery store is also an important additional component mainstream retailers need to consider. The United States Potato Board developed product placement strategies and suggestions in retail marketing toolkit that is readily available for merchandisers on the USPB website (USPB, 2001). This toolkit suggests that premium and specialty potatoes be ordered first in grocery store displays near high traffic areas to attract impulse buyers.

Another option for product placement is directly selling Colorado specialty potatoes at farmers' markets. For some growers, farmers' markets may be a good product outlet, especially if production levels are too low to support contract sales and/or the grower prefers to direct market their product to consumers who value locally-grown products. Indeed there are several growers that currently practice direct to consumer marketing methods such as sales at farmers markets (Miller Family Farms) and road/farm-side stands (Rockey Farms). Additionally, Colorado specialty potatoes could be sold at front-range farmers markets to generate market penetration; selling Colorado specialty potatoes at summer farmers markets could prime the local retail grocery stores market for the winter months when farmers markets are less frequently held.

An additional placement opportunity is “pull strategy” where local chefs in the desired distributional area feature Colorado specialty potatoes as part of the menu. For example, restaurants on the front range of Colorado could include Colorado specialty potatoes (highlighting the locally grown attribute) as a side offering to the entre food item. This strategy would encourage consumers to try the product, and then later would ask their local grocery store about where Colorado specialty potatoes can be purchased. Grocery stores would then request that distributors begin to supply Colorado specialty potatoes to meet in the increased demand from consumers. Fundamentally, the goal of this strategy is for consumers to gain experience and acceptance of Colorado specialty potatoes at a restaurant, then seek for the product at their local grocery store.

*4.3.4 Promotion*

Promotional strategies must effectively communicate the merits of Colorado specialty potatoes to the target markets. This is accomplished by first understanding what the target market core consumer needs, then by communicating to the consumers that specialty potatoes can assist to fulfill those needs. What also should be considered as an element of promotional activities are the unique aspects of Colorado specialty potatoes, and how these aspects differ from competing products in meaningful ways to the consumer. The Colorado specialty potatoes included in our study each have several attributes that are valued by consumers in the identified target markets. These include: enhanced nutritional properties (anti-carcinogenic, high levels of resistant starch, high levels of antioxidants), appealing flavors, texture, and visual properties, and the inherent locally-grown aspects of the Colorado cultivars.

Products in the introduction and growth phase of the product life cycle tend to benefit greatly from retailer and consumer education about the product (Kotler and Armstrong, 2007; Nelson, 1974). Informative promotion can be expected to benefit relatively new products in which the consumer has relatively little knowledge about much more relative to products in the maturity phase of the product life cycle (Day, 1981). Although more consumers are linking diet and overall wellness and health, research has shown that consumers lack knowledge on aspects of required daily nutrition (IFIC, 2009). Specifically and with respect to specialty potatoes, research has found consumers were least knowledgeable about nutritional content relative to all other attributes (Bond et al., 2011). This suggests that the new specialty potatoes, such as fingerlings and antioxidant rich pigmented cultivars, could benefit greatly from direct informational promotion directed at to the consumer. Colorado specialty potatoes can be positioned to take advantage of the local food movement, but in order to do so must clearly communicate this feature to the consumer. This can be best accomplished by visually informing the consumer that the product was grown in Colorado. Labeling the potato bag with visuals and viewable signs at the grocery store can effectively communicate this message. The “Colorado Proud” label is an additional way to communicate this message to consumers at the grocery store.

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Since the "foodie" culture has a fascination with new and exciting information on cuisine that comes from food oriented magazines, television shows, websites, and online blogs, it would be appropriate to develop a promotional strategy in these media formats. For example, an updated modern website designed to be the sole online resource for Colorado specialty potatoes would be a low cost and widely available promotional tool for this target market. Included on the website could be seasonal recipes for specialty potatoes, locations where consumers can purchase the product, and explicit information on why Colorado specialty potatoes provide a better eating experience relative to other products. This website could have an overall execution style that has homemade and crafty feel that conveys a message of quality about the product.

Another format that could reach this target market are visually appealing advertisements in food magazines along paired unique recipe ideas that have an execution style that promotes a quality product would be a way to reach this market. One example of a magazine that could be an appropriate fit for such for this advertisement would be the magazine, *Sunset*. This magazine focuses on lifestyle in the modern American west, and could be a good outlet to reach "foodies" as well as consumers who seek to purchase locally grown foods. In fact, the *Sunset Magazine* website had 181 recipe results for potatoes under the “food and wine” category; recipe subcategories include “holidays and occasions,” “flavors of the West,” and “healthy” (Sunset, 2012). This suggests that an advertisement in *Sunset* for Colorado specialty potatoes would reach all of the target markets identified for this product.

The results from this study found few significant effects on potato consumption during the weeks prior to and containing the holidays of Easter, 4th of July, Thanksgiving, and Christmas. Fingerling and red potatoes were the only varieties that had significant increases in consumption during the weeks containing these holidays among the five cities compared in this study. However, Bond and Richards (2008) found significant positive results for holiday variables in their study. Their results, along with the evidence from the relative search frequency from Google Trends suggest that an increase in consumption during major American holidays is likely (Google Inc., 2012). Specifically, the USPB retail toolkit says that the months from November through January are peak selling months, which is due to increased demand during the Thanksgiving and Christmas holiday seasons (USPB, 2001). Despite the results in this showing few significant changes in demand for potatoes during the holiday season, it is still recommended that retailers consider promotional activities for during holiday seasons. One such example of seasonal promotion can be seen in Table 4.4 in the pricing strategy subsection of this chapter. A two pound bag labeled as “Star Spangled” fingerlings were for sale prior to Memorial Day 2012 at King Soopers in Fort Collins, CO. These potatoes were simply a mixed bag of red, white, and blue fingerling potatoes, but the careful and creative promotional strategy prior to this major U.S. holiday adds value, and provides evidence of the marketing opportunities that holidays can provide.

4.4 Generalizations to the Colorado and Front Range Markets

One limitation of the econometric model in this paper is the limited opportunity for generalizing to the Colorado and Front Range markets. Since the results indicate that a great deal of heterogeneity exists between the five cities in the dataset, estimating or predicting price sensitivity for Colorado and the Front Range is not possible. However, a demographic comparison of Colorado and the Front Range with the five cities (Atlanta, Chicago, Dallas, Los Angeles, and New York) may offer some insight when developing a more complete marketing plan.

Table 4.7 shows demographic characteristics for the Atlanta, Chicago, Dallas, Los Angeles, New York, and Denver Metropolitan Statistical Areas, as well as for the State of Colorado in 2008. The population characteristics were collected from the U.S. Census Bureau (2010), while the obesity rates were collected from the Centers for Disease Control (2008). This table shown estimated population, percent of the population with a bachelor's degree or higher, the median age, the percent of the population that identifies as "white only," mean and median income per household, and the percent of the population with considered obese with a BMI of greater than 30 (Centers for Disease Control and Prevention, 2008).

Table 4.7 Demographic Characteristics for Atlanta, Chicago, Dallas, Los Angeles, New York, Denver, and Colorado in 2008

| | Population | Education (%) | Age | Race | Mean income ($) | Median income ($) | Obesity rate (%) |
|---|---|---|---|---|---|---|---|
| **Atlanta** | 5368070 | 34.6 | 35 | 57.9 | 80494 | 60682 | 24.7 |
| **Chicago** | 9568532 | 33.0 | 35.7 | 66.4 | 82623 | 61295 | 26.3 |
| **Dallas** | 6303407 | 29.6 | 33.3 | 69.7 | 77705 | 56377 | 28.2 |
| **Los Angeles** | 12872808 | 29.9 | 35.1 | 55.2 | 85966 | 60264 | 23.3 |
| **New York** | 19006798 | 35.2 | 38.1 | 61.1 | 108214 | 77760 | 21.4 |
| **Denver** | 2500384 | 37.5 | 35.9 | 82 | 81497 | 60897 | 19.3 |
| ***Colorado*** | 4889730 | 35.6 | 35.8 | 84.8 | 77343 | 57885 | 19.3 |

Data from: U.S. Census Bureau, 2010; Centers for Disease Control and Prevention, 2008)

The population estimates show that Denver has far less number of residents in 2008 (roughly 2.5 million people) compared the five cities compared in this study. In fact, the entire State of Colorado had fewer residents than each of the five cities in this study with 4.9 million residents. Colorado and Denver also had a higher percent of the population with a bachelor's degree or higher compared to the other five cities. New York was most comparable to Denver and Colorado with 35.2%, 37.5%, and 35.6% of the population with a bachelor's degree or higher. The median age for Colorado and Denver (35.8 and 35.9) was least comparable to New York and Los Angeles at 38.1 and 33.3 years, respectively. This table also reveals that a significantly higher proportion of the population in Colorado and Denver identified as "white only." In terms of income levels, Colorado compares similarly to Atlanta, Chicago, Dallas, and Los Angeles. The City of Denver best compares to Dallas in terms of income measures. Lastly, both Colorado and Denver had significantly less percent of the residential population consider obese compared to Atlanta, Chicago, Dallas, and Los Angeles. New York had slightly higher rates of obesity compared to Colorado and Denver, with 21.4% and 19.3% of the population, respectively.

Based off of this table, it is proves difficult to generalize one city evaluated in the econometric portion of this paper with the Colorado and Denver markets. However, what can be said is that overall, Colorado and Denver had a smaller resident population, tend to be healthier, are more likely to identify from European descent, and more educated than the five cities compared in this paper. Although residents of Colorado and Denver did not necessarily have the highest income levels compared the other five cities, this metric is not accounting for cost of living, which very well could be less expensive in Colorado and Denver. Given the econometric results in this study, it is likely that consumers in the Colorado and Front Range markets are relatively more sensitive to changes in price of specialty potatoes relative to Russet potatoes.

### 4.5 Marketing Limitations and Future Considerations

An important component of marketing Colorado specialty potatoes is to consider what the target market needs and desires, then appropriately manage how the product being offered meets those needs. With the three target market segments identified as health conscious consumers, "foodies," and consumers who seek locally grown food, Colorado specialty potatoes have the opportunity to meet the needs of these target markets by providing a unique, nutritional, and locally grown product these consumer groups desire. Through promotional activities, appropriate pricing strategies, and product placement, Colorado specialty potatoes can be marketed for success. However, what is recommended to the Colorado Potato Administrative Committee is the need for a more thorough market analysis than what has been presented in the current chapter of this paper. The most recent work from Bond et al. (2011) has provided a good foundation to better understand the preferences of Colorado consumers with respect to specialty potatoes, but more can be done. A recommended next step is to conduct in store consumer experiments to collect revealed preference data in combination with purchaser demographic information. In the next phase of the grant-funded research project, a more complete marketing plan will be developed and will include an extended SWOT analysis (TOWS), a budget, and detailed implementation plans. Further coordination with CPAC and individual growers will further inform the marketing objectives and provide additional guidance on feasible marketing strategies.

# CHAPTER 5: CONCLUSIONS AND EXTENSIONS

## 5.1 Summary Thoughts

The emergence of increased consumer demand for fresh specialty potato varieties may provide opportunity for the Colorado potato industry. However, limited market level data on consumer behavior for new specialty cultivars exists. Previous studies have evaluated consumer demand for potatoes at the varietal level (Bond and Richards, 2008; Hsieh, Mitchell, and Stiegert, 2009), but none have estimated and compared consumer demand between multiple cities. Using Deaton and Muellbauer's (1980) linear approximate almost ideal demand system, this paper recovered price and expenditure elasticities for each of the five cities where the data were collected. This paper found that specialty potato varieties had a higher mean price per pound at the point of sale, but were generally more price sensitive than the well-established Russet potato variety. This study also found that specialty potatoes had a positive trend in consumption, while the well-established cultivars, such as red, white, and Russet, tended to have a negative trend in consumption. This suggests growth in the specialty potato consumer market, and indicates signs of slippage in the well-established commodity potato market. However, the inconsistency of sign and significance of the trend variable per variety across cities provides evidence of significant heterogeneity in consumption patterns. The parameter results also indicated few changes in consumption for all potato varieties during the holiday seasons. However, preliminary testing and data observation lead to the suspicion that holiday effects are present, but model misspecification may be to blame for failing to find many significant holiday effects on consumption. The most important contribution of this study is providing evidence that substantial differences exist in potato consumption between the five cities in this study. The results show that the own-price and expenditure elasticities for each variety rang significantly across the five cities in this study. All varieties in this study were found to have varying levels of sensitivity to prices; some potato varieties had a range from inelastic to highly elastic in some cities. Similarly, this study also found varying levels of response in consumption with respect to changes in expenditure by variety across the five cities. The results also found that in four of the five cities, consumer demand for specialty potatoes is more sensitive to price relative to Russet potatoes The exception in is in New York, we consumer demand for Russet potatoes was found to be more sensitive to price than fingerling and creamer potatoes. The econometric results in this paper provide evidence that consumer demand for potatoes is heterogeneous between different U.S. cities, and should be considered when developing marketing strategies.

## 5.2 Limitations

There are a number of limitations to the results from this study the reader should be aware of. The first limitation that should be highlighted is the relative age of the data. The most recent observation in the data was recorded nearly four years prior to the writing of this paper. The second limitation for the Colorado potato industry is the concern of how generalizable the results from this paper are to a Colorado consumer marker, knowing that a significant amount of heterogeneity exists between the cities studied in this paper. The third limitation of the results presented in this paper is the chance of poorly chosen instrumental variables used in testing for endogenous prices (see section 3.2). Although the instruments applied by Hausman, Leonard, and Zona (1994) proved to be better than the lagged endogenous variables, given the frequency of negative chi-square values in the latter, the former instruments still reported one negative test statistic for the creamer variety in the New York system. This suggest that that the instruments from Hausman, Leonard, and Zona may not be the best available for this dataset. An additional method that was not explored in this study involves the specification of price equations, which reflect strategic firm behavior and supply costs (see Kadiyali, Vilcussium and Chintagunta, 1996; Dhar, Chavas, and Gould, 2003). The fourth limitation of the results presented in this paper is the failure to test for endogenous expenditure on the potato category. Previous studies have found evidence of an endogenous expenditure in systems of demand equations that assume weak separability of goods (Dhar, Chavas, and Gould, 2003; Kadiyali, Vilcassium, and Chintagunta. 1996; LaFrance, 1991). However, this paper did not include a test for endogenous expenditure on the potato category due to data limitations and lack of sufficient instrumental variables available to the researcher. An additional approach that future research should consider to correct both endogenous prices and expenditure is to estimate the system of equations using a generalize method of moments estimator. The fifth limitation of this paper is from modeling time series data with a static long-run model. This is likely incorrectly accounting for the dynamic nature of the data. By ignoring the dynamic nature of the time series data, the model is likely inducing autocorrelated errors (Deaton and Muellbauer, 1980). The sixth limitation of this paper is how the multi-stage budgeting of the potato category from all other goods was assumed. By assuming weak separability, but then including the natural logged prices of rice and pasta as explanatory variables, this study incorrectly specified the theoretical model.

## 5.3 Future Research

Building off of the work presented in this paper, a number of future efforts in the econometric estimation procedure can be made. First, future modeling with this data should consider a two-stage estimation process would allow for a more complete demand system

(Edgerton, 1997). This type of modeling would allow for estimation of pricing relationship between the substitute goods (rice and pasta) with the potato category in the first-stage, while the second-stage would only model demand at the varietal level. Second, a dynamic system of demand equations should be considered when evaluating consumer demand using time series data; a first-differenced almost ideal demand system may be sufficient to meet this recommendation. Third, better instruments should be developed in testing and correcting for endogenous prices and expenditure. Fourth, Berndt and Savin's (1975) technique for correcting autocorrelated errors in a singular system of equation should be applied in future modeling efforts.

Given the heterogeneity of consumer behavior estimated in this paper, it is recommended that in order to market new Colorado specialty potatoes effectively, site specific promotional programs as opposed to broad generalized program must be developed. Further, the Colorado Potato Administrative Committee should develop a more thorough market analysis of the target market and distribution region than what has been presented in the chapter 4 of this paper. This paper and the work from Bond et al. (2011) has provided a good foundation to better understand the market for Colorado specialty potatoes, but more can be done. In store sampling consumers in Colorado must be conducted to better understand the needs of the target market. The Colorado potato industry needs to recognize that the data and trends presented in this paper have their limitations. Ultimately, a more complete marketing plan must be developed beyond what is presented in this paper.

The last recommendation for future research is to estimate a system of demand equations with a greater emphasis on comparing organic and conventionally grown potato varieties. In this study, organic potatoes were aggregated into one variety. However, if enough data were available, an important contribution to the literature could be made by comparing potato varieties when both organically and conventionally grow. For example, this future research would develop a system of demand equations that includes a conventionally grown red potato as well as an organically grown red potato; a conventionally grown Russet, and an organically grown Russet, and so on. For this study, aggregating the organic potato varieties was necessary due to data limitations and in effort to minimize specification bias. However, future research should compare different cultivars across production methods.

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# APPENDIX A: ORGANIC POTATO VARIETIES IN THE SYSTEM OF DEMAND EQUATIONS

Lack of observations, inconsistent periods of sales, and small volume of sales relative to conventionally grown potato varieties were issues for many of the organic varieties in the dataset. To reduce the specification bias in the model, the eleven organic potatoes varieties were aggregated into one "organic" variety. To aggregate the organic potato varieties into one variety, the pounds purchased were summed while a weighted average of prices was calculated from the eleven individual organic potato varieties. The remainder of subsection 2.4.2 provides a discussion on the respective organic varieties prior to aggregation. This discussion was included in this paper because

Figure 2.1 shows the total pounds of organic potatoes sold in the five cities during 2006 through 2008. This figure shows that New York had the largest number with more than 5.3 million pounds sold during this time. Each with less than half of the total pounds sold in New York, the cities of Chicago, Los Angeles, and Atlanta had roughly 2.5 million, 1.8 million, and 1.5 million, respectively.  Dallas had the fewest during this time with 0.5 million pounds of organic potatoes. This appears to suggest that New Yorkers may be more likely to purchase organic potatoes than the four other cities included in this study. However, this figure ignores the differences in population size as a contributing factor in organic pounds sold. It also ignores the size of organic potato pounds sold relative to the total pounds of potatoes sold, both organic and conventional.

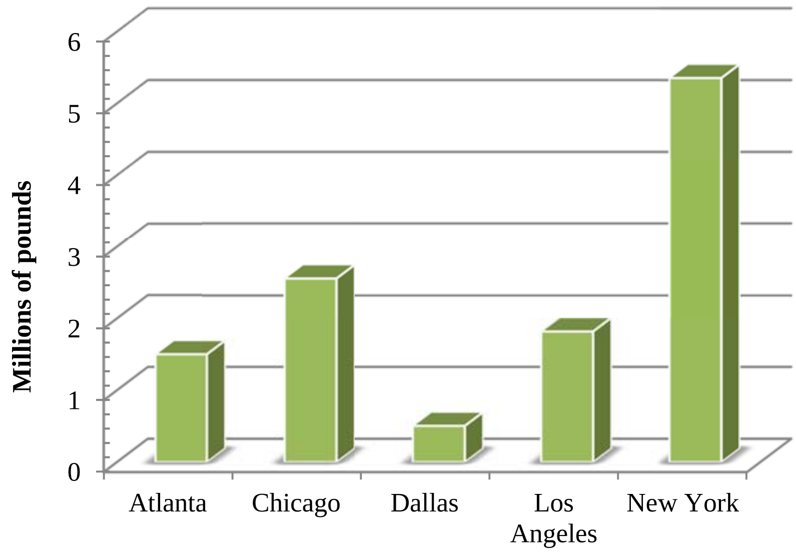


**Figure A.1 Total Number of Organic Pounds Sold from 2006 -2008**

Figure 2.2 offers a different perspective on organic potato pounds sold from 2006 to 2008 between the five cities. This figure shows what percent share of total pounds of potatoes were organic during this time. Figure 5 contrasts with figure 3 by showing that New Yorkers may not have necessarily eaten more organic potatoes relative to the other cities where the data were collected. In Atlanta and Chicago, organic potatoes had a higher percent share of total pounds of potatoes sold than in New York during this time.

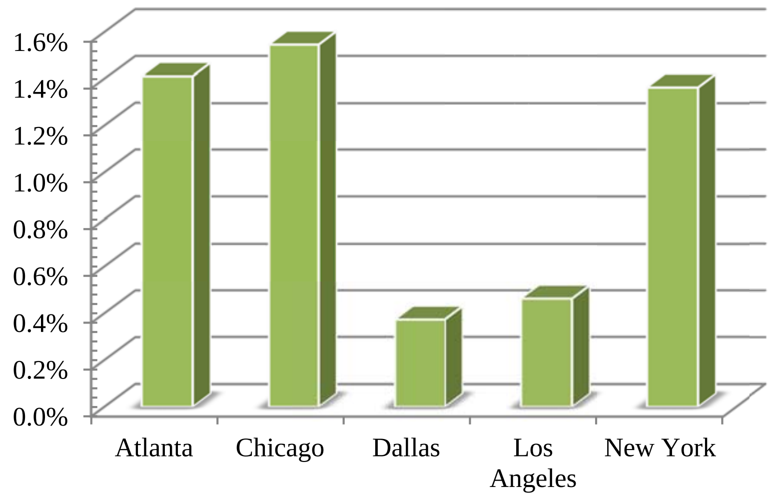


**Figure A.2 Percent Organic of Total Potato Pounds Sold from 2006 - 2008**

Figure 2.3 shows the distribution of total pounds sold for each organic variety, prior to aggregation, between the five cities during 2006 to 2008. This figure highlights an unequal distribution of pounds sold among organic varieties between cities. Organic Idaho potatoes shown in red had the bulk of the total pounds sold in Atlanta and Chicago, with few pounds sold in the remaining three cities. Organic Russets shown in purple had a large number of pounds sold in Los Angeles and New York during this time. Dallas had the fewest number of pounds sold for all organic potato varieties.

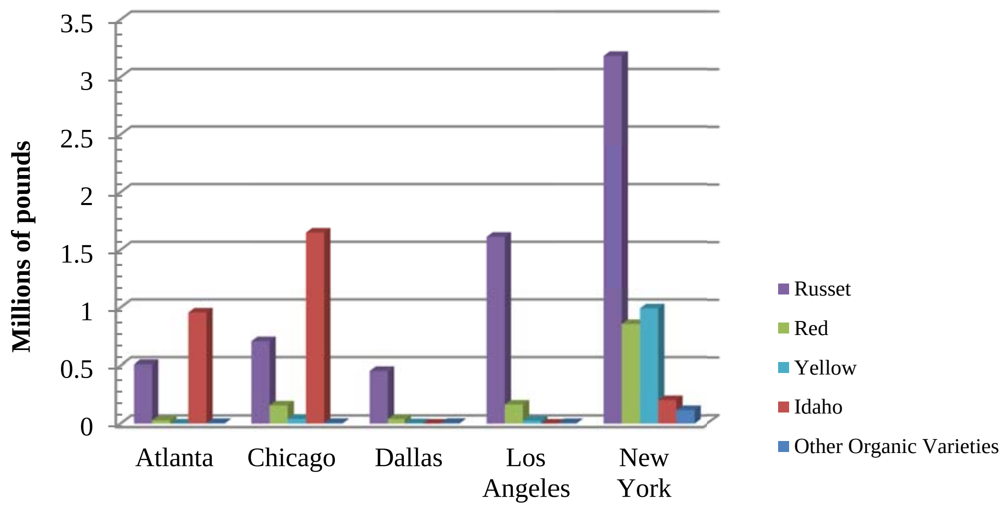


**Figure A.3 Organic Potato Pounds Sold By Variety from 2006 to 2008**

This section highlighted some of the differences between the organic potato varieties prior to aggregation. Figure 2.1 shows how New York had the largest number of organic potato pounds sold during 2006 through 2008. Figure 2.2 tells a slightly different story, that as a percent share of total pounds of potatoes sold during this time, there may not be a significant difference between frequency of consumption between New York, Chicago, and Atlanta. This figure also describes an important justification for aggregating the organic potato varieties: as a percent share of total potato pounds sold from 2006 to 2008, organic potatoes had a relatively small share in each city, ranging from 0.37% to 1.55% of all potatoes sold during this time. Comparatively, conventional Russet potatoes captured upwards of 61% of total pounds of potatoes during this time (see section 2.5 for summary statistics).

# APPENDIX B: CONSIDERATIONS FOR POTATO SUBSTITUTES AND COMPLEMENTS

It may be reasonable to assume one of the following three cases: consumers have a fresh produce budget, a carbohydrate budget or, that a budget for potatoes is an independent process separate from all other goods. In the former two cases, potatoes are assumed to be part of a greater budgeting process. Two recommendations were offered after presenting preliminary findings from this study at a graduate symposium. One recommendation was from a professor, while the other from a peer colleague. The first suggestion was to including the price of other fresh vegetables in the modeling process, while the second was to include the price of sweet potatoes. However, no other studies have a demand system that includes  potatoes and sweet potatoes, but previous research has modeled potatoes as part of a greater fresh produce budgeting process (Zhang et al. 2006..  Following these suggestions and previous work, prices of other fresh vegetables and sweet potatoes were considered for inclusion in this study (USDA-ERS and BLS). However, it proved to be not possible to find reliable sweet potato prices that matched the 2006 through 2008 data collection period. The best available data for other fresh vegetables from the Bureau of Labor Statistics were monthly prices for lettuce, tomatoes, and broccoli was found on a national level. Ultimately, the inclusion prices of the fresh vegetable data were deeming inappropriate for the econometric estimation.

# APPENDIX C: GOOGLE TRENDS SEARCH RESULTS

Section 2.3 describes the linear approximate almost ideal demand system, which included a description of seasonal effects on consumer demand for potatoes. Bond and Richards (2008) argued that significant seasonal effects existed in potato consumption, primarily during the winter months of the year. Further evidence of seasonal effects on potato consumption was sound when considering the Google Trends frequency for “potato” searches during January 1, 2006 through September 28, 2008 as shown in Figure 6.1 (Google Inc., 2012)

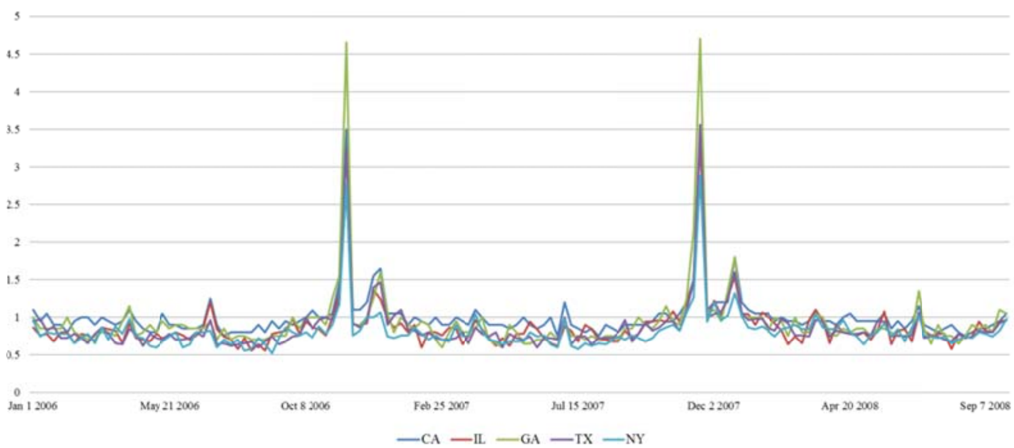


**Figure C.1 Google Trends Search Frequenc for "Potato" from January 1, 2006 to September 28, 2008**

The relative search frequencies in this data were normalized by the mean search volume conditional on the time period selected by the researcher. In this case, when the relative search frequency was reported to fall below 1 indicates that the number of searches for “potato” from the specified locations fell below the mean search frequency. As shown in Figure 6.1, the two spikes in relative search frequency, each with values well above 1, fall near Thanksgiving and Christmas of 2006 and 2007, respectively. This provides evidence that consumer demand for potatoes, at least consumer interest in potatoes, increases during times of holiday events; most notably during Thanksgiving and Christmas.

APPENDIX D: POTATO PRICES BY VARIETY OVER TIME

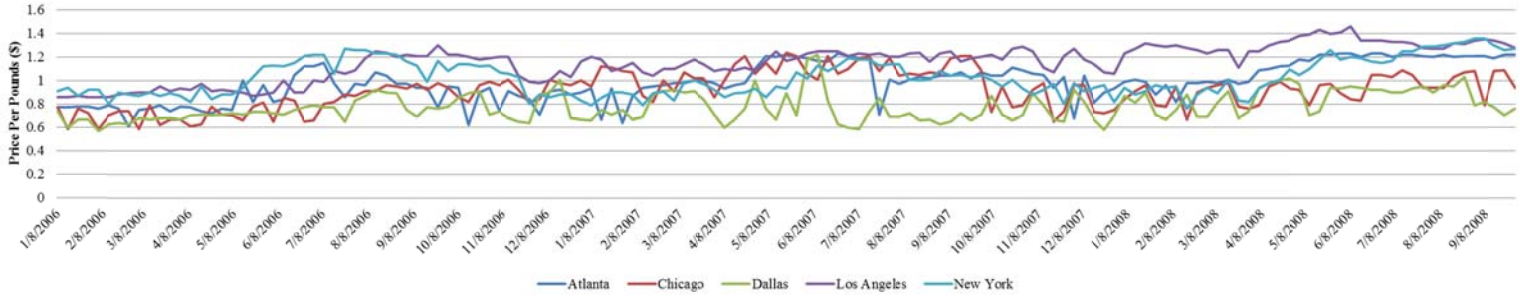


**Figure D.1: Weekly Price of Yellow Potatoes by City from January 8, 2006 to September 28, 2008**

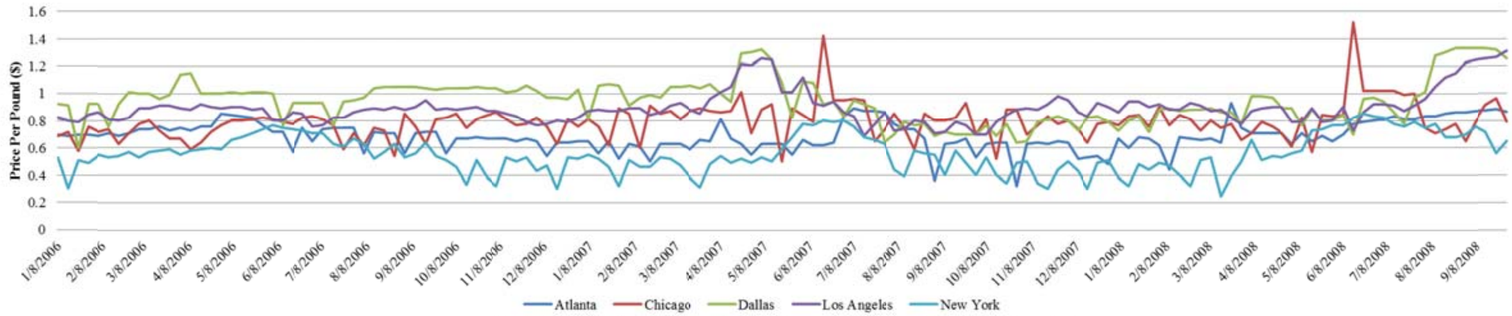


**Figure D.2: Weekly Price of White Potatoes by City from January 8, 2006 to September 28, 2008**

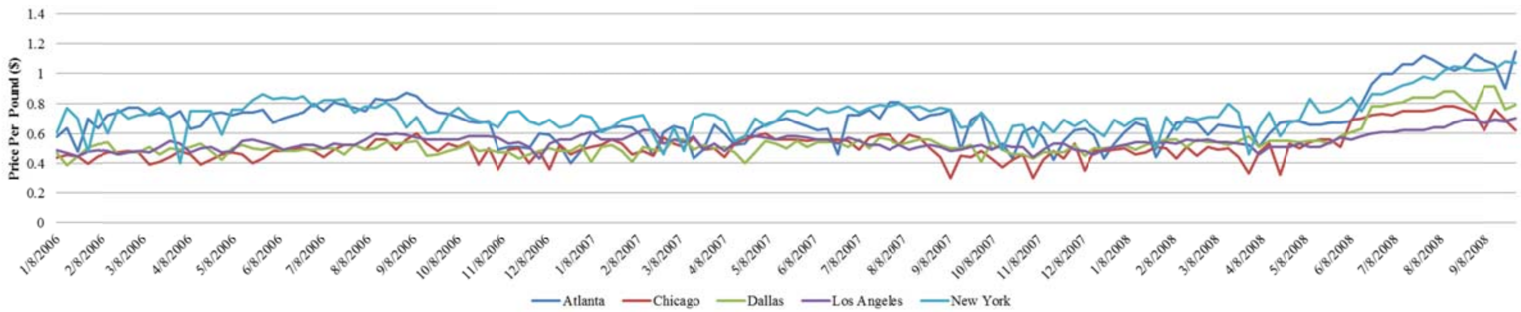


**Figure D.3: Weekly Price of Russet Potatoes by City from January 8, 2006 to September 28, 2008**


**Figure D.4: Weekly Price of Fingerling Potatoes by City from January 8, 2006 to September 28, 2008**

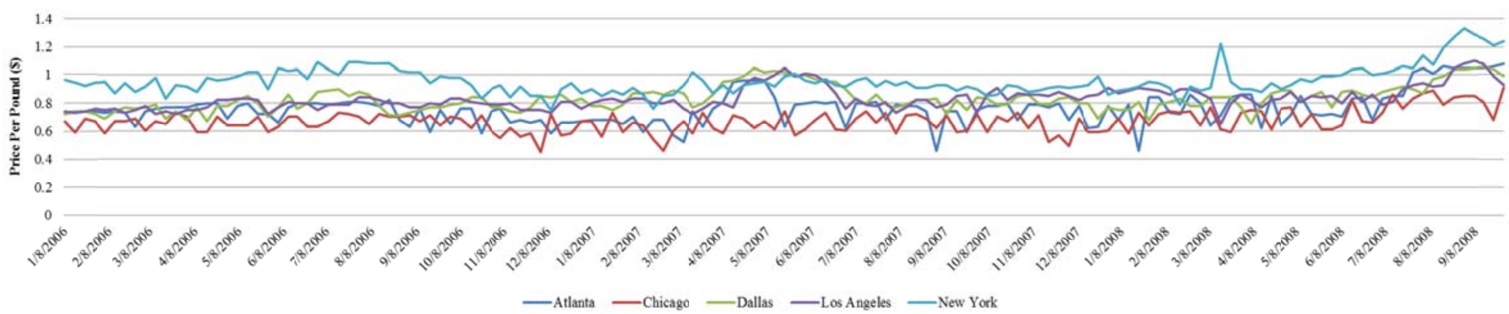


**Figure D.5: Weekly Price of Red Potatoes by City from January 8, 2006 to September 28, 2008**

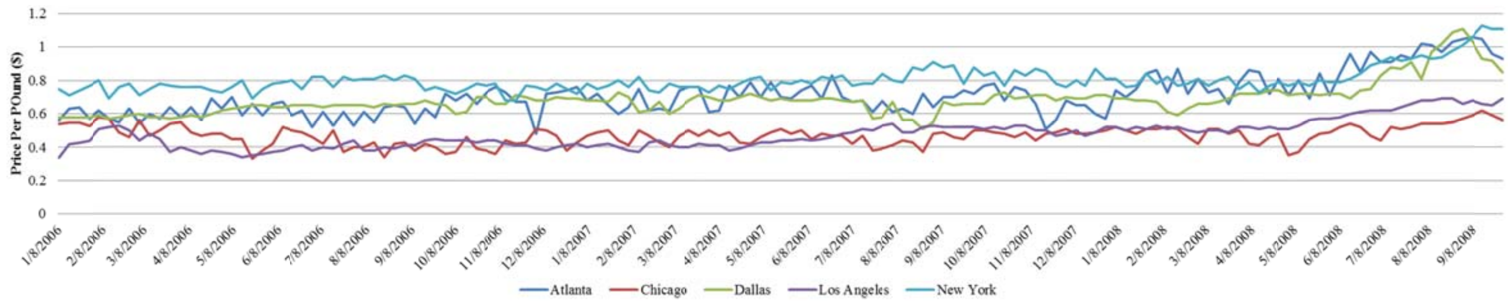


**Figure D.6: Weekly Price of Idaho Potatoes by City from January 8, 2006 to September 28, 2008**

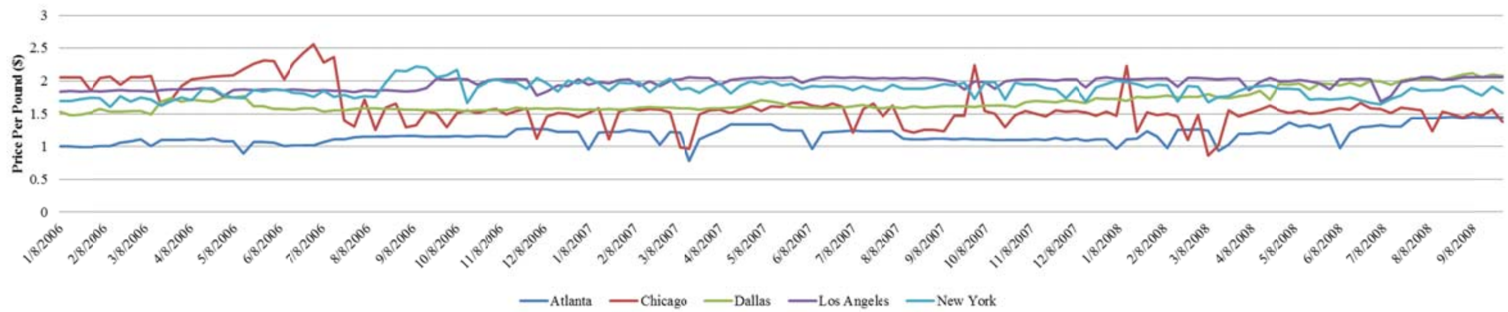


**Figure D.7: Weekly Price of Creamer Potatoes by City from January 8, 2006 to September 28, 2008**


**Figure D.8: Weekly Price of Organic Poatoes by City from January 8, 2006 to September 28, 2008**

# APPENDIX E: PARAMETER ESTIMATES USING LAGGED ENDOGENOUS VARIABLES AS INSTRUMENTS

Table E.1: Atlant Parameter Estimates Using Lagged Endogenous Instrumental Variables

| | yellow | white | Russet | fingerling | red | Idaho | creamer |
|---|---|---|---|---|---|---|---|
| $\ln(P_{yellow})$ | **-0.042** | **0.013** | **-0.010** | **-0.001** | **-0.016** | **0.043** | **0.013** |
| | (0.001) | (0.099) | (0.519) | (0.144) | (0.318) | (0.007) | (0.072) |
| $\ln(P_{white})$ | **0.013** | **-0.064** | **-0.025** | **0.000** | **0.022** | **0.047** | **-0.001** |
| | (0.099) | (0.000) | (0.146) | (0.550) | (0.103) | (0.006) | (0.876) |
| $\ln(P_{Russet})$ | **-0.010** | **-0.025** | **0.109** | **0.002** | **0.024** | **-0.135** | **0.006** |
| | (0.519) | (0.146) | (0.028) | (0.103) | (0.296) | (0.001) | (0.580) |
| $\ln(P_{fingerling})$ | **-0.001** | **0.000** | **0.002** | **-0.002** | **0.001** | **0.001** | **-0.001** |
| | (0.144) | (0.550) | (0.103) | (0.000) | (0.437) | (0.465) | (0.132) |
| $\ln(P_{red})$ | **-0.016** | **0.022** | **0.024** | **0.001** | **-0.037** | **-0.018** | **0.027** |
| | (0.318) | (0.103) | (0.296) | (0.437) | (0.287) | (0.515) | (0.021) |
| $\ln(P_{Idaho})$ | **0.043** | **0.047** | **-0.135** | **0.001** | **-0.018** | **0.083** | **-0.006** |
| | (0.007) | (0.006) | (0.001) | (0.465) | (0.515) | (0.097) | (0.600) |
| $\ln(P_{creamer})$ | **0.013** | **-0.001** | **0.006** | **-0.001** | **0.027** | **-0.006** | **-0.031** |
| | (0.072) | (0.876) | (0.580) | (0.132) | (0.021) | (0.600) | (0.000) |
| $\ln(P_{organic})$ | **0.000** | **0.008** | **0.029** | **0.000** | **-0.003** | **-0.015** | **-0.007** |
| | (0.993) | (0.264) | (0.054) | (0.742) | (0.804) | (0.349) | (0.187) |
| ln(X/P) | **0.025** | **-0.013** | **0.077** | **0.000** | **-0.041** | **-0.075** | **-0.012** |
| | (0.019) | (0.466) | (0.104) | (0.856) | (0.018) | (0.128) | (0.135) |
| holiday | **-0.005** | **-0.010** | **-0.002** | **0.000** | **0.010** | **0.006** | **0.002** |
| | (0.215) | (0.101) | (0.927) | (0.564) | (0.081) | (0.736) | (0.464) |
| trend | **0.043** | **-0.016** | **-0.001** | **0.001** | **0.025** | **-0.062** | **0.012** |
| | (0.000) | (0.183) | (0.973) | (0.012) | (0.072) | (0.063) | (0.064) |
| $\ln(P_{rice})$ | **0.011** | **-0.106** | **0.188** | **-0.003** | **-0.067** | **0.004** | **-0.023** |
| | (0.585) | (0.000) | (0.008) | (0.012) | (0.031) | (0.961) | (0.100) |
| $\ln(P_{pasta})$ | **-0.096** | **0.186** | **-0.094** | **0.003** | **0.042** | **-0.077** | **0.021** |
| | (0.000) | (0.000) | (0.259) | (0.030) | (0.202) | (0.393) | (0.154) |
| $w_{t-1}$ | **0.299** | **0.503** | **0.505** | **0.693** | **0.306** | **0.461** | **0.440** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Constant | **-0.292** | **0.164** | **-0.793** | **0.003** | **0.590** | **1.188** | **0.200** |
| | (0.046) | (0.495) | (0.214) | (0.683) | (0.012) | (0.074) | (0.065) |
| $R^2$ | 0.681 | 0.774 | 0.615 | 0.863 | 0.313 | 0.424 | 0.509 |

p-values are shown below estimated coeffieicnts in parentheses

Table E.2: Chicago Parameter Estimates Using Lagged Endogenous Instrumental Variables

| | yellow | white | Russet | fingerling | red | Idaho | creamer |
|---|---|---|---|---|---|---|---|
| $\ln(P_{yellow})$ | **-0.046** | **0.012** | **0.035** | **0.000** | **-0.030** | **0.003** | **0.029** |
| | (0.006) | (0.535) | (0.004) | (0.947) | (0.170) | (0.907) | (0.048) |
| $\ln(P_{white})$ | **0.012** | **-0.029** | **0.007** | **-0.001** | **0.065** | **-0.033** | **-0.013** |
| | (0.535) | (0.474) | (0.619) | (0.810) | (0.035) | (0.288) | (0.528) |
| $\ln(P_{Russet})$ | **0.035** | **0.007** | **-0.098** | **-0.001** | **0.027** | **-0.008** | **0.041** |
| | (0.004) | (0.619) | (0.000) | (0.499) | (0.185) | (0.735) | (0.003) |
| $\ln(P_{fingerling})$ | **0.000** | **-0.001** | **-0.001** | **-0.003** | **0.002** | **0.000** | **0.002** |
| | (0.947) | (0.810) | (0.499) | (0.032) | (0.260) | (0.839) | (0.208) |
| $\ln(P_{red})$ | **-0.030** | **0.065** | **0.027** | **0.002** | **-0.023** | **-0.093** | **0.023** |
| | (0.170) | (0.035) | (0.185) | (0.260) | (0.647) | (0.041) | (0.344) |
| $\ln(P_{Idaho})$ | **0.003** | **-0.033** | **-0.008** | **0.000** | **-0.093** | **0.194** | **-0.060** |
| | (0.907) | (0.288) | (0.735) | (0.839) | (0.041) | (0.004) | (0.037) |
| $\ln(P_{creamer})$ | **0.029** | **-0.013** | **0.041** | **0.002** | **0.023** | **-0.060** | **-0.014** |
| | (0.048) | (0.528) | (0.003) | (0.208) | (0.344) | (0.037) | (0.508) |
| $\ln(P_{organic})$ | **-0.003** | **-0.008** | **-0.002** | **0.000** | **0.030** | **-0.002** | **-0.007** |
| | (0.637) | (0.539) | (0.610) | (0.876) | (0.013) | (0.847) | (0.321) |
| ln(X/P) | **0.013** | **-0.054** | **-0.005** | **0.000** | **0.053** | **-0.043** | **0.042** |
| | (0.299) | (0.000) | (0.788) | (0.706) | (0.017) | (0.165) | (0.003) |
| holiday | **-0.003** | **0.000** | **-0.011** | **0.000** | **0.009** | **0.012** | **-0.010** |
| | (0.601) | (0.972) | (0.238) | (0.805) | (0.279) | (0.330) | (0.096) |
| trend | **0.035** | **-0.018** | **0.150** | **0.000** | **-0.093** | **-0.094** | **0.011** |
| | (0.006) | (0.206) | (0.000) | (0.720) | (0.000) | (0.000) | (0.450) |
| $\ln(P_{rice})$ | **-0.036** | **-0.015** | **0.075** | **0.002** | **0.110** | **-0.075** | **-0.054** |
| | (0.151) | (0.587) | (0.080) | (0.383) | (0.007) | (0.148) | (0.054) |
| $\ln(P_{pasta})$ | **0.026** | **-0.016** | **-0.177** | **-0.001** | **0.019** | **0.123** | **0.031** |
| | (0.408) | (0.617) | (0.001) | (0.717) | (0.711) | (0.058) | (0.372) |
| $w_{t-1}$ | **0.343** | **0.320** | **0.280** | **0.475** | **0.316** | **0.270** | **0.320** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Constant | **-0.136** | **0.845** | **0.211** | **0.009** | **-0.537** | **0.799** | **-0.582** |
| | (0.444) | (0.000) | (0.416) | (0.445) | (0.088) | (0.074) | (0.004) |
| $R^2$ | 0.448 | 0.688 | 0.628 | 0.554 | 0.539 | 0.256 | 0.494 |

p-values are shown below estimated coeffieicnts in parentheses

Table E.3: Dallas Parameter Estimates Using Lagged Endogenous Instrumental Variables

| | yellow | white | Russet | fingerling | red | Idaho | creamer |
|---|---|---|---|---|---|---|---|
| $\ln(P_{yellow})$ | **-0.019** | **0.007** | **0.016** | **-0.002** | **0.006** | **-0.007** | **0.000** |
| | (0.003) | (0.024) | (0.115) | (0.039) | (0.283) | (0.434) | (0.910) |
| $\ln(P_{white})$ | **0.007** | **0.004** | **0.008** | **-0.003** | **0.004** | **-0.009** | **-0.004** |
| | (0.024) | (0.474) | (0.195) | (0.044) | (0.407) | (0.270) | (0.296) |
| $\ln(P_{Russet})$ | **0.016** | **0.008** | **0.001** | **0.002** | **0.004** | **-0.033** | **-0.002** |
| | (0.115) | (0.195) | (0.971) | (0.509) | (0.768) | (0.167) | (0.720) |
| $\ln(P_{fingerling})$ | **-0.002** | **-0.003** | **0.002** | **-0.003** | **0.005** | **0.002** | **0.002** |
| | (0.039) | (0.044) | (0.509) | (0.000) | (0.009) | (0.407) | (0.150) |
| $\ln(P_{red})$ | **0.006** | **0.004** | **0.004** | **0.005** | **-0.041** | **0.015** | **0.008** |
| | (0.283) | (0.407) | (0.768) | (0.009) | (0.000) | (0.192) | (0.067) |
| $\ln(P_{Idaho})$ | **-0.007** | **-0.009** | **-0.033** | **0.002** | **0.015** | **0.022** | **0.008** |
| | (0.434) | (0.270) | (0.167) | (0.407) | (0.192) | (0.398) | (0.276) |
| $\ln(P_{creamer})$ | **0.000** | **-0.004** | **-0.002** | **0.002** | **0.008** | **0.008** | **-0.012** |
| | (0.910) | (0.296) | (0.720) | (0.150) | (0.067) | (0.276) | (0.071) |
| $\ln(P_{organic})$ | **0.001** | **-0.007** | **0.004** | **-0.002** | **0.001** | **0.001** | **0.001** |
| | (0.677) | (0.003) | (0.171) | (0.008) | (0.768) | (0.730) | (0.661) |
| ln(X/P) | **0.030** | **-0.022** | **0.046** | **-0.001** | **-0.016** | **-0.035** | **-0.008** |
| | (0.000) | (0.000) | (0.038) | (0.730) | (0.092) | (0.039) | (0.072) |
| holiday | **-0.004** | **-0.003** | **0.004** | **0.001** | **0.007** | **-0.005** | **0.000** |
| | (0.139) | (0.055) | (0.553) | (0.104) | (0.017) | (0.363) | (0.804) |
| trend | **0.010** | **-0.006** | **0.018** | **0.001** | **-0.013** | **-0.016** | **0.008** |
| | (0.028) | (0.083) | (0.154) | (0.483) | (0.023) | (0.101) | (0.008) |
| $\ln(P_{rice})$ | **-0.008** | **0.007** | **0.168** | **-0.007** | **-0.030** | **-0.102** | **-0.019** |
| | (0.483) | (0.261) | (0.000) | (0.006) | (0.024) | (0.000) | (0.004) |
| $\ln(P_{pasta})$ | **-0.010** | **-0.005** | **-0.115** | **0.007** | **0.024** | **0.075** | **0.016** |
| | (0.523) | (0.520) | (0.006) | (0.032) | (0.161) | (0.012) | (0.041) |
| $w_{t-1}$ | **0.586** | **0.549** | **0.579** | **0.618** | **0.554** | **0.613** | **0.543** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Constant | **-0.395** | **0.337** | **-0.345** | **0.009** | **0.263** | **0.488** | **0.121** |
| | (0.000) | (0.000) | (0.246) | (0.702) | (0.038) | (0.032) | (0.031) |
| $R^2$ | 0.666 | 0.715 | 0.688 | 0.757 | 0.582 | 0.796 | 0.771 |

p-values are shown below estimated coeffieicnts in parentheses

Table E.4: Los Angeles Parameter Estimates Using Lagged Endogenous Instrumental Variables

| | yellow | white | Russet | fingerling | red | Idaho | creamer |
|---|---|---|---|---|---|---|---|
| $\ln(P_{yellow})$ | **0.001** | **0.002** | **-0.009** | **0.001** | **-0.012** | **0.007** | **0.006** |
| | (0.836) | (0.595) | (0.331) | (0.260) | (0.116) | (0.074) | (0.137) |
| $\ln(P_{white})$ | **0.002** | **0.000** | **-0.016** | **-0.001** | **0.020** | **-0.006** | **0.003** |
| | (0.595) | (0.967) | (0.088) | (0.088) | (0.049) | (0.253) | (0.477) |
| $\ln(P_{Russet})$ | **-0.009** | **-0.016** | **-0.122** | **-0.003** | **0.024** | **0.117** | **0.001** |
| | (0.331) | (0.088) | (0.000) | (0.102) | (0.299) | (0.000) | (0.888) |
| $\ln(P_{fingerling})$ | **0.001** | **-0.001** | **-0.003** | **-0.004** | **0.004** | **-0.001** | **0.001** |
| | (0.260) | (0.088) | (0.102) | (0.016) | (0.005) | (0.369) | (0.357) |
| $\ln(P_{red})$ | **-0.012** | **0.020** | **0.024** | **0.004** | **-0.021** | **-0.004** | **-0.004** |
| | (0.116) | (0.049) | (0.299) | (0.005) | (0.409) | (0.727) | (0.583) |
| $\ln(P_{Idaho})$ | **0.007** | **-0.006** | **0.117** | **-0.001** | **-0.004** | **-0.113** | **0.000** |
| | (0.074) | (0.253) | (0.000) | (0.369) | (0.727) | (0.000) | (0.962) |
| $\ln(P_{creamer})$ | **0.006** | **0.003** | **0.001** | **0.001** | **-0.004** | **0.000** | **-0.004** |
| | (0.137) | (0.477) | (0.888) | (0.357) | (0.583) | (0.962) | (0.492) |
| $\ln(P_{organic})$ | **0.004** | **-0.001** | **0.009** | **0.002** | **-0.006** | **-0.001** | **-0.003** |
| | (0.036) | (0.326) | (0.027) | (0.010) | (0.038) | (0.720) | (0.161) |
| ln(X/P) | **0.017** | **-0.010** | **-0.024** | **0.000** | **-0.009** | **0.030** | **-0.004** |
| | (0.000) | (0.010) | (0.060) | (0.507) | (0.349) | (0.001) | (0.110) |
| holiday | **-0.001** | **-0.002** | **0.006** | **0.000** | **0.001** | **-0.004** | **0.000** |
| | (0.493) | (0.356) | (0.291) | (0.026) | (0.850) | (0.265) | (0.915) |
| trend | **0.016** | **-0.008** | **-0.018** | **0.000** | **0.013** | **-0.004** | **0.000** |
| | (0.000) | (0.021) | (0.116) | (0.635) | (0.108) | (0.525) | (0.910) |
| $\ln(P_{rice})$ | **-0.026** | **0.021** | **0.043** | **-0.001** | **-0.028** | **0.003** | **-0.010** |
| | (0.000) | (0.007) | (0.075) | (0.473) | (0.135) | (0.847) | (0.152) |
| $\ln(P_{pasta})$ | **-0.003** | **-0.008** | **-0.008** | **0.003** | **0.009** | **0.006** | **0.001** |
| | (0.668) | (0.381) | (0.790) | (0.004) | (0.671) | (0.737) | (0.823) |
| $w_{t-1}$ | **0.497** | **0.553** | **0.557** | **0.686** | **0.552** | **0.562** | **0.617** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Constant | **-0.264** | **0.181** | **0.655** | **0.007** | **0.185** | **-0.403** | **0.076** |
| | (0.000) | (0.002) | (0.001) | (0.306) | (0.189) | (0.002) | (0.063) |
| $R^2$ | 0.851 | 0.608 | 0.858 | 0.781 | 0.193 | 0.929 | 0.424 |

p-values are shown below estimated coeffieicnts in parentheses

| Table E.5: New York Parameter Estimates Using Lagged Endogenous Instrumental Variables | | | | | | | |
|---|---|---|---|---|---|---|---|
| | yellow | white | Russet | fingerling | red | Idaho | creamer |
| $\ln(P_{yellow})$ | **-0.002** | **0.012** | **0.059** | **0.001** | **-0.003** | **-0.046** | **-0.017** |
| | (0.917) | (0.160) | (0.032) | (0.612) | (0.873) | (0.004) | (0.056) |
| $\ln(P_{white})$ | **0.012** | **-0.081** | **-0.004** | **0.000** | **0.023** | **0.041** | **0.019** |
| | (0.160) | (0.000) | (0.780) | (0.527) | (0.235) | (0.000) | (0.000) |
| $\ln(P_{Russet})$ | **0.059** | **-0.004** | **-0.138** | **0.004** | **-0.049** | **0.079** | **0.013** |
| | (0.032) | (0.780) | (0.024) | (0.240) | (0.225) | (0.006) | (0.430) |
| $\ln(P_{fingerling})$ | **0.001** | **0.000** | **0.004** | **-0.001** | **-0.001** | **-0.001** | **0.000** |
| | (0.612) | (0.527) | (0.240) | (0.266) | (0.339) | (0.419) | (0.884) |
| $\ln(P_{red})$ | **-0.003** | **0.023** | **-0.049** | **-0.001** | **0.017** | **0.033** | **0.002** |
| | (0.873) | (0.235) | (0.225) | (0.339) | (0.784) | (0.188) | (0.843) |
| $\ln(P_{Idaho})$ | **-0.046** | **0.041** | **0.079** | **-0.001** | **0.033** | **-0.104** | **-0.007** |
| | (0.004) | (0.000) | (0.006) | (0.419) | (0.188) | (0.000) | (0.458) |
| $\ln(P_{creamer})$ | **-0.017** | **0.019** | **0.013** | **0.000** | **0.002** | **-0.007** | **-0.017** |
| | (0.056) | (0.000) | (0.430) | (0.884) | (0.843) | (0.458) | (0.038) |
| $\ln(P_{organic})$ | **-0.003** | **-0.009** | **0.037** | **0.000** | **-0.022** | **0.005** | **0.007** |
| | (0.758) | (0.089) | (0.010) | (0.728) | (0.015) | (0.474) | (0.153) |
| ln(X/P) | **0.050** | **0.001** | **-0.044** | **0.001** | **-0.015** | **0.010** | **-0.007** |
| | (0.000) | (0.910) | (0.021) | (0.284) | (0.567) | (0.386) | (0.241) |
| holiday | **0.000** | **-0.002** | **-0.006** | **0.000** | **0.017** | **-0.008** | **0.002** |
| | (0.965) | (0.759) | (0.512) | (0.963) | (0.136) | (0.107) | (0.344) |
| trend | **0.035** | **-0.004** | **0.019** | **0.001** | **-0.033** | **-0.039** | **0.022** |
| | (0.000) | (0.673) | (0.221) | (0.489) | (0.108) | (0.000) | (0.000) |
| $\ln(P_{rice})$ | **-0.059** | **0.057** | **0.122** | **-0.004** | **-0.006** | **-0.058** | **-0.034** |
| | (0.004) | (0.009) | (0.004) | (0.046) | (0.904) | (0.015) | (0.011) |
| $\ln(P_{pasta})$ | **-0.016** | **-0.029** | **-0.090** | **0.001** | **0.069** | **0.056** | **-0.002** |
| | (0.474) | (0.292) | (0.029) | (0.580) | (0.285) | (0.029) | (0.862) |
| $w_{t-1}$ | **0.286** | **0.320** | **0.297** | **0.451** | **0.299** | **0.277** | **0.372** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Constant | **-0.686** | **0.035** | **0.900** | **-0.013** | **0.368** | **-0.011** | **0.147** |
| | (0.000) | (0.829) | (0.001) | (0.292) | (0.315) | (0.947) | (0.094) |
| $R^2$ | 0.310 | 0.708 | 0.493 | 0.185 | 0.077 | 0.726 | 0.569 |

p-values are shown below estimated coeffieicnts in parentheses

APPENDIX F: STATA COMMANDS

```
/// symmetry restrictions
constraint 9 [w1]lnp2=[w2]lnp1
constraint 10 [w1]lnp3=[w3]lnp1
constraint 11 [w1]lnp4=[w4]lnp1
constraint 12 [w1]lnp5=[w5]lnp1
constraint 13 [w1]lnp6=[w6]lnp1
constraint 14 [w1]lnp7=[w7]lnp1
constraint 15 [w1]lnp8=[w8]lnp1
constraint 16 [w2]lnp3=[w3]lnp2
constraint 17 [w2]lnp4=[w4]lnp2
constraint 18 [w2]lnp5=[w5]lnp2
constraint 19 [w2]lnp6=[w6]lnp2
constraint 20 [w2]lnp7=[w7]lnp2
constraint 21 [w2]lnp8=[w8]lnp2
constraint 22 [w3]lnp4=[w4]lnp3
constraint 23 [w3]lnp5=[w5]lnp3
constraint 24 [w3]lnp6=[w6]lnp3
constraint 25 [w3]lnp7=[w7]lnp3
constraint 26 [w3]lnp8=[w8]lnp3
constraint 27 [w4]lnp5=[w5]lnp4
constraint 28 [w4]lnp6=[w6]lnp4
```

constraint 29 [w4]lnp7=[w7]lnp4

constraint 30 [w4]lnp8=[w8]lnp4

constraint 31 [w5]lnp6=[w6]lnp5

constraint 32 [w5]lnp7=[w7]lnp5

constraint 33 [w5]lnp8=[w8]lnp5

constraint 34 [w6]lnp7=[w7]lnp6

constraint 35 [w6]lnp8=[w8]lnp6

constraint 36 [w7]lnp8=[w8]lnp7

/// homogeneity restrictions

constraint 1 [w1]lnp1 + [w1]lnp2 + [w1]lnp3 + [w1]lnp4 + [w1]lnp5 +[w1]lnp6 +[w1]lnp7 +[w1]lnp8 = 0

constraint 2 [w2]lnp1 + [w2]lnp2 + [w2]lnp3 + [w2]lnp4 + [w2]lnp5 +[w2]lnp6 +[w2]lnp7 +[w2]lnp8 = 0

constraint 3 [w3]lnp1 + [w3]lnp2 + [w3]lnp3 + [w3]lnp4 + [w3]lnp5 +[w3]lnp6 +[w3]lnp7 +[w3]lnp8 = 0

constraint 4 [w4]lnp1 + [w4]lnp2 + [w4]lnp3 + [w4]lnp4 + [w4]lnp5 +[w4]lnp6 +[w4]lnp7 +[w4]lnp8 = 0

constraint 5 [w5]lnp1 + [w5]lnp2 + [w5]lnp3 + [w5]lnp4 + [w5]lnp5 +[w5]lnp6 +[w5]lnp7 +[w5]lnp8 = 0

constraint 6 [w6]lnp1 + [w6]lnp2 + [w6]lnp3 + [w6]lnp4 + [w6]lnp5 +[w6]lnp6 +[w6]lnp7 +[w6]lnp8 = 0

```
constraint 7 [w7]lnp1 + [w7]lnp2 + [w7]lnp3 + [w7]lnp4 + [w7]lnp5 +[w7]lnp6 +[w7]lnp7
+[w7]lnp8 = 0
constraint 8 [w8]lnp1 + [w8]lnp2 + [w8]lnp3 + [w8]lnp4 + [w8]lnp5 +[w8]lnp6 +[w8]lnp7
+[w8]lnp8 = 0



///Price elasticities without correcting for endogeneity
reg3 (w1 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w1_1) (w2 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w2_1) (w3 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w3_1) (w4 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w4_1) (w5 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w5_1) (w6 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w6_1) (w7 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w7_1),  constraints(1 2 3 4 5 6 7 9 10 11 12 13 14 16 17 18 19 20 22 23 24 25 27 28 29 31 32
34) ireg3

sum w1, meanonly
scalar w1_mean=r(mean)
sum w2, meanonly
scalar w2_mean=r(mean)
sum w3, meanonly
scalar w3_mean=r(mean)
```

```
sum w4, meanonly

scalar w4_mean=r(mean)

sum w5, meanonly

scalar w5_mean=r(mean)

sum w6, meanonly

scalar w6_mean=r(mean)

sum w7, meanonly

scalar w7_mean=r(mean)

sum w8, meanonly

scalar w8_mean=r(mean)


/// equation 1 own and cros price elasticities

nlcom  (-1 + ([w1]lnp1-[w1]lnxp_1*w1_mean)/w1_mean)            ///

              (([w1]lnp2-[w1]lnxp_1*w2_mean)/w1_mean)           ///

              (([w1]lnp3-[w1]lnxp_1*w3_mean)/w1_mean)           ///


              (([w1]lnp4-[w1]lnxp_1*w4_mean)/w1_mean)           ///

              (([w1]lnp5-[w1]lnxp_1*w5_mean)/w1_mean)           ///

              (([w1]lnp6-[w1]lnxp_1*w6_mean)/w1_mean)           ///

              (([w1]lnp7-[w1]lnxp_1*w7_mean)/w1_mean)           ///

              (([w1]lnp8-[w1]lnxp_1*w8_mean)/w1_mean)


/// equation 2 own and cross price elasticities:
```

```
nlcom (([w2]lnp1-[w2]lnxp_1*w1_mean)/w2_mean)                    ///
 (-1 + ([w2]lnp2-[w2]lnxp_1*w2_mean)/w2_mean)                    ///
            (([w2]lnp3-[w2]lnxp_1*w3_mean)/w2_mean)              ///
            (([w2]lnp4-[w2]lnxp_1*w4_mean)/w2_mean)              ///
            (([w2]lnp5-[w2]lnxp_1*w5_mean)/w2_mean)              ///
            (([w2]lnp6-[w2]lnxp_1*w6_mean)/w2_mean)              ///
            (([w2]lnp7-[w2]lnxp_1*w7_mean)/w2_mean)              ///
            (([w2]lnp8-[w2]lnxp_1*w8_mean)/w2_mean)


/// equation 3 own and cross price elastiticities:
nlcom (([w3]lnp1-[w3]lnxp_1*w1_mean)/w3_mean)                    ///
            (([w3]lnp2-[w3]lnxp_1*w2_mean)/w3_mean)              ///
 (-1 + ([w3]lnp3-[w3]lnxp_1*w3_mean)/w3_mean)                    ///


            (([w3]lnp4-[w3]lnxp_1*w4_mean)/w3_mean)              ///
            (([w3]lnp5-[w3]lnxp_1*w5_mean)/w3_mean)              ///
            (([w3]lnp6-[w3]lnxp_1*w6_mean)/w3_mean)              ///
            (([w3]lnp7-[w3]lnxp_1*w7_mean)/w3_mean)              ///
            (([w3]lnp8-[w3]lnxp_1*w8_mean)/w3_mean)


/// equation 4 own and cross price elastiticiteis
nlcom (([w4]lnp1-[w4]lnxp_1*w1_mean)/w4_mean)                    ///
            (([w4]lnp2-[w4]lnxp_1*w2_mean)/w4_mean)              ///
```

```
              (([w4]lnp3-[w4]lnxp_1*w3_mean)/w4_mean)                   ///
 (-1 + ([w4]lnp4-[w4]lnxp_1*w4_mean)/w4_mean)                   ///


              (([w4]lnp5-[w4]lnxp_1*w5_mean)/w4_mean)                   ///
              (([w4]lnp6-[w4]lnxp_1*w6_mean)/w4_mean)                   ///
              (([w4]lnp7-[w4]lnxp_1*w7_mean)/w4_mean)                   ///
              (([w4]lnp8-[w4]lnxp_1*w8_mean)/w4_mean)


/// equation 5 own and cross price elasticities
nlcom (([w5]lnp1-[w5]lnxp_1*w1_mean)/w5_mean)                   ///
              (([w5]lnp2-[w5]lnxp_1*w2_mean)/w5_mean)                   ///
              (([w5]lnp3-[w5]lnxp_1*w3_mean)/w5_mean)                   ///
              (([w5]lnp4-[w5]lnxp_1*w4_mean)/w5_mean)                   ///
 (-1 + ([w5]lnp5-[w5]lnxp_1*w5_mean)/w5_mean)                   ///


              (([w5]lnp6-[w5]lnxp_1*w6_mean)/w5_mean)                   ///
              (([w5]lnp7-[w5]lnxp_1*w7_mean)/w5_mean)                   ///
              (([w5]lnp8-[w5]lnxp_1*w8_mean)/w5_mean)


/// equation 6 own and cross price elasticities
nlcom (([w6]lnp1-[w6]lnxp_1*w1_mean)/w6_mean)                   ///
              (([w6]lnp2-[w6]lnxp_1*w2_mean)/w6_mean)                   ///
              (([w6]lnp3-[w6]lnxp_1*w3_mean)/w6_mean)                   ///
```

```
            (([w6]lnp4-[w6]lnxp_1*w4_mean)/w6_mean)                 ///
            (([w6]lnp5-[w6]lnxp_1*w5_mean)/w6_mean)                 ///
 (-1 + ([w6]lnp6-[w6]lnxp_1*w6_mean)/w6_mean)                       ///

            (([w6]lnp7-[w6]lnxp_1*w7_mean)/w6_mean)                 ///
            (([w6]lnp8-[w6]lnxp_1*w8_mean)/w6_mean)

/// equation 7 own and cross price elasticities
nlcom (([w7]lnp1-[w7]lnxp_1*w1_mean)/w7_mean)                       ///
            (([w7]lnp2-[w7]lnxp_1*w2_mean)/w7_mean)                 ///
            (([w7]lnp3-[w7]lnxp_1*w3_mean)/w7_mean)                 ///
            (([w7]lnp4-[w7]lnxp_1*w4_mean)/w7_mean)                 ///
            (([w7]lnp5-[w7]lnxp_1*w5_mean)/w7_mean)                 ///
            (([w7]lnp6-[w7]lnxp_1*w6_mean)/w7_mean)                 ///
 (-1 + ([w7]lnp7-[w7]lnxp_1*w7_mean)/w7_mean)                       ///

            (([w7]lnp8-[w7]lnxp_1*w8_mean)/w7_mean)

/// command for organic elasticity estimates (yellow w1 dropped)
reg3 (w8 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w8_1) (w2 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w2_1) (w3 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w3_1) (w4 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
```

```
w4_1) (w5 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w5_1) (w6 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w6_1) (w7 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w7_1), ///
constraints(2 3 4 5 6 7 8 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36) ireg3
///
exog(a2 a3 a5 a6 d2 d3 d5 d6 c2 c3 c5 c6 la2 la3 la5 la6) endog(lnp2 lnp3 lnp5 lnp6)
sum w1, meanonly
scalar w1_mean=r(mean)
sum w2, meanonly
scalar w2_mean=r(mean)
sum w3, meanonly
scalar w3_mean=r(mean)
sum w4, meanonly
scalar w4_mean=r(mean)
sum w5, meanonly
scalar w5_mean=r(mean)
sum w6, meanonly
scalar w6_mean=r(mean)
sum w7, meanonly
scalar w7_mean=r(mean)
sum w8, meanonly
scalar w8_mean=r(mean)
```

```
/// equation 8 own and cross price elasticities
nlcom (([w8]lnp1-[w8]lnxp_1*w1_mean)/w8_mean)              ///
      (([w8]lnp2-[w8]lnxp_1*w2_mean)/w8_mean)              ///
      (([w8]lnp3-[w8]lnxp_1*w3_mean)/w8_mean)              ///
      (([w8]lnp4-[w8]lnxp_1*w4_mean)/w8_mean)              ///
      (([w8]lnp5-[w8]lnxp_1*w5_mean)/w8_mean)              ///
      (([w8]lnp6-[w8]lnxp_1*w6_mean)/w8_mean)              ///
      (([w8]lnp7-[w8]lnxp_1*w7_mean)/w8_mean)
///
 (-1 + ([w8]lnp8-[w8]lnxp_1*w8_mean)/w8_mean)


///Expenditure elasticities without correcting for endogeneity
reg3 (w1 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w1_1) (w2 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w2_1) (w3 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w3_1) (w4 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w4_1) (w5 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w5_1) (w6 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w6_1) (w7 = lnp1 lnp2 lnp3 lnp4 lnp5 lnp6 lnp7 lnp8 lnxp_1 holiday trend lnp_rice lnp_spgt
w7_1),  constraints(1 2 3 4 5 6 7 9 10 11 12 13 14 16 17 18 19 20 22 23 24 25 27 28 29 31 32
34) ireg3
```

```
sum w1, meanonly

scalar w1_mean=r(mean)

sum w2, meanonly

scalar w2_mean=r(mean)

sum w3, meanonly

scalar w3_mean=r(mean)

sum w4, meanonly

scalar w4_mean=r(mean)

sum w5, meanonly

scalar w5_mean=r(mean)

sum w6, meanonly

scalar w6_mean=r(mean)

sum w7, meanonly

scalar w7_mean=r(mean)

sum w8, meanonly

scalar w8_mean=r(mean)



nlcom (1 + ([w1]lnxp_1)/w1_mean)            ///

    (1 + ([w2]lnxp_1)/w2_mean)            ///

    (1 + ([w3]lnxp_1)/w3_mean)            ///

    (1 + ([w4]lnxp_1)/w4_mean)            ///
```

```
(1 + ([w5]lnxp_1)/w5_mean)                    ///
(1 + ([w6]lnxp_1)/w6_mean)                    ///
(1 + ([w7]lnxp_1)/w7_mean)                    ///
        (1 + (-[w1]lnxp_1 - [w2]lnxp_1 - [w3]lnxp_1 - [w4]lnxp_1 - [w5]lnxp_1 - [w6]lnxp_1 -
[w7]lnxp_1)/w8_mean)
```

## APPENDIX G: NUTRITIONAL QUALITIES COLORADO-GROWN SPECIALTY POTATO VARIETIES

**Russet Burbank**

(Medium Size)

- Low Calorie (110 calories)
- High Fiber (8% daily recommended value or DV)
- High in Potassium (18% DV)
- Vitamin C (45% DV)
- Vitamin B6 (10%)
- Iron (6% DV)

**Rio Grande Russet**

(Medium Size)

- Low Calorie (110 calories)
- High Fiber (8% daily recommended value or DV)
- High in Potassium (18% DV)
- Vitamin C (Greater than 45% DV)
- Vitamin B6 (10%)
- Iron (6% DV)
- Very high levels of resistant starch-aids in mineral absorption
- High in phenolics and glykoalcaloids-shown to inhibit cancer development

**Lady Pinto**

(Medium Size)

- Low Calorie (110 calories)
- High Fiber (8% daily recommended value or DV)
- High in Potassium (18% DV)
- Vitamin C (Greater than 45% DV)
- Vitamin B6 (10%)
- Iron (6% DV)

**Aspen Russet**

(Medium Size)

- Low Calorie (110 calories)
- High Fiber (8% daily recommended value or DV)
- High in Potassium (18% DV)
- Vitamin C (45% DV)
- Vitamin B6 (10%)
- Iron (6% DV)

**Purple Majesty**

(Medium Size)

- Low Calorie (110 calories)
- High Fiber (8% daily recommended value or DV)
- High in Potassium (18% DV)
- Vitamin C (45% DV)
- Vitamin B6 (10%)
- Iron (6% DV)
- Very high levels of antioxidants and phenolics-shown to inhibit cancer growth and development