Spatial and Temporal Linkages in U.S. Potato Prices*

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Abstract

In recent years regional weather patterns have had an unusually strong effect on potato production and prices across the country in all marketing seasons. The quantitative impact of changes in potato production in one marketing region on prices in others is not currently known. These linkages, however, are quite important for decision makers in the industry in planning marketing strategies. This study examines the relationships among prices and quantities of potatoes across regions and seasons.

Own- and cross-price flexibilities are estimated using Pooled Time Series and Cross-Sectional methods for winter, spring, summer, as well as eastern, central, and western fall potato production. Significant impacts of own-regional production on prices are found. Price responses to changes in own-production differ among seasons and regions, and important linkages are found as well. Of the fall producing regions, central and western production changes are found to have a dominant impact on prices in their own and other regions and seasons. Production changes in the minor seasons are found to be less important in determining prices in regions and seasons other than their own.

These price flexibility results are used to estimate the impact of the 1990 increases in fall

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potato acreage on regional fall and subsequent seasonal prices. Although the largest percentage acreage increase and price decrease occur in the western fall region, central fall and summer prices are estimated to also experience percentage decreases in price greater than the percentage increase in western fall production.

Introduction

Regional and seasonal potato markets are linked through common end uses and regional market competition. Tablestock potatoes from the western states, for example, are sold alongside potatoes from the north central and the northeastern states in markets along the eastern seaboard. Changes in potato production during a particular season or within a given region of production, therefore, have impacts on the potato prices in subsequent seasons and in other regions. Planting decisions in one region or season can affect potato prices in geographically distant markets and over time. To date, however, information on the magnitudes of these spatial and temporal linkages in potato markets has not been available.

Raunikar, Purcell and Elrod found some evidence of distinct geographical differences in potato demand, but did not examine the regional price flexibilities necessary to establish formal regional linkages. Goodwin, Fuller, Capps and Asgill investigated factors affecting the terminal market prices of several retail packs of fresh potatoes and found that marketing season is an important price determinant. Their study, while limited to a subset of tablestock varieties and terminal markets, does provide some evidence of the market linkages of interest in this study.

A more comprehensive model of the U.S. potato industry was developed by Beilock and Dunn to estimate the impacts of changes in energy cost on production, and the successive activities from planting to marketing within each season and region was specified by a recursive system of equations. Whereas Beilock and Dunn's study provides estimations of the structural characteristics of the potato industry, additional knowledge of the dynamic price linkages between regional and seasonal potato markets has numerous applications for industry participants. In particular, the ability to predict price changes throughout the entire national market that are the result of production changes within an individual region or season and/or the effects on an individual region or market season may provide a significant planning aid for purchase and contract strategies for processors and for planting and harvest strategies for growers.

We present here an empirical model that considers only the quantities and prices for a single marketing year. There are, of course, other determinants of price not included here. Our interest in this study is to develop a simple short-run price prediction model that can be used by buyers and sellers during the marketing year to make informed decisions. Estimation of the determination of the determinants of long-run market equilibrium is beyond the scope of this work.

An interesting case in point occurred in 1990. Across the nation, potato producers have enjoyed relatively high crop prices for the past few growing seasons. These high prices are largely the result of extreme summer drought in some of the potato production regions. In response to these high prices, there was a significant expansion of acreage planted to potatoes in 1990 in the fall potato producing regions. This expansion was most significant in the west (a 9% increase in planted acreage in 1990), while central and eastern producers have undertaken two percent and 0.5 percent expansions, (USDA a). These production increases affected prices in other regions and seasons.

The objective of this study is to establish the potato price linkages within one marketing year that result from production changes at the regional/seasonal level. These measurements are then used to predict regional price changes resulting from the significant fall potato acreage increases that occurred during the 1990 growing season.

We begin with a recursive model of potato price response to production changes through four seasons beginning with the three regions of fall production. Results from the estimation of this model yield own and cross-aggregate farm-gate price flexibilities. These flexibilities are then ap-

plied to the acreage changes (and predicted production changes) observed in the 1990 fall crop to determine their effects on subsequent seasons.

Regional and Seasonal Differences In Potato Markets

The price effects of production changes differ among seasons and regions. Reasons for these differences include: the sizes of local markets, distances and transport costs to other markets, storage costs among seasons and differences in the mix and end use of potato varieties produced in the distinct seasons and regions.

Potatoes are produced in the United States throughout the year. The fall season is, by far, the most important, accounting for more than 87 percent of national annual production. The fall crop is commonly divided into three major producing areas. The largest of these is the west, which includes all states west of Colorado except Arizona and New Mexico and accounts for more than 55 percent of annual production. The north-central region produces around 19 percent of the annual crop and includes the Dakotas, Nebraska, Indiana and the northern Lakes States. Northeast production accounts for about 13 percent of annual production and includes most of the states from Maine to Ohio. Since there is inter-market transfer among the fall producing regions, we expect production changes in any fall producing region to affect prices in the other two fall regions as well as in the home region. The effect of changes in the fall producing regions on prices would, in turn, have an impact on prices in succeeding winter, spring and summer crops as well.

Winter potatoes are produced only in California and Florida and make up less than one percent of the annual crop. Spring production occurs in most of the southernmost tier of states and North Carolina. Spring production accounts for about six percent of the annual crop. Summer production takes place in many regionally diverse states and is responsible for about six percent of the annual crop (USDA b).

Price Response Model and Estimation Method

A set of six recursive equations is specified to measure the spatial/temporal relationships among potato prices and production. In equations one through three, fall potato prices (P) in the east (fe), central (fc), and west (fw) are hypothesized to be a function of their own production and the production of the other two regions (Q) in year t, so that,

$$P_{fe,t} = F_1(Q_{fe,t}, Q_{fc,t}, Q_{fw,t}) \quad (1)$$

$$P_{fc,t} = F_2(Q_{fc,t}, Q_{fe,t}, Q_{fw,t}) \quad (2)$$

$$P_{fw,t} = F_3(Q_{fw,t}, Q_{fe,t}, Q_{fc,t}) \quad (3)$$

Fall markets are thought to be highly interdependent. Because of the relatively large size of the fall crop, fall prices were found to be independent of the previous season's prices and production in our preliminary estimation.

Equations four through six reflect the price interrelationships among the seasons. In addition to the own-quantity effect on prices, we hypothesize that price in the minor season--winter (wi), spring (sp), or summer (su)--is determined by its own production and the prices in preceding seasons. This reflects both competition from stocks of previous seasons and the effects of price information on the planting and harvest in subsequent seasons. Because of length-of-storage constraints, however, fall production should not influence prices directly in the following fall season or beyond. They may, however, influence future planting decisions and, thus, impact the succeeding year's prices indirectly. These second-round effects are not considered explicitly in this study, since we are interested only in predictions of price changes within the marketing year to be used in short-term planning decisions. The results of responses to previous years' prices are considered implicitly, however, through the acreage decisions in year t embodied in the production regressors.

Equation four represents the effect of only the fall regional prices on the winter crop.

Because the winter crop competes directly with the fall crop, and represents such a small proportion of the annual crop, we might expect winter prices to be almost perfectly correlated with fall prices. However, for the winter crop, it is possible to "store in the ground," that is, harvest according to price, so that the price effects of the fall crop are mitigated for the winter crop.

$$P_{wi,t} = F_4(Q_{wi,t}, P_{fe,t-1}, Q_{fc,t-1}, P_{fw,t-1}) \quad (4)$$

The spring crop price response model is similar to the winter model. Spring potatoes compete with the last of the fall crop and the small winter crop. Planting and harvest decisions are hypothesized to depend on price information from both of these seasons.

$$P_{sp,t} = F_5(Q_{sp,t}, P_{wi,t}, P_{fe,t-1}, P_{fc,t-1}, P_{fw,t-1}) \quad (5)$$

The summer harvest occurs when annual stocks are at their lowest, and thus summer prices may be largely independent of other season prices. However, to allow for the possibility of other season effects, previous season prices are included in the summer price model.

$$P_{su,t} = F_6(Q_{su,t}, P_{sp,t}, P_{wi,t}, P_{fe,t-1}, P_{fc,t-1}, P_{fw,t-1}) \quad (6)$$

To allow for contemporaneous correlation of errors among equations, equations (1) through (6) are estimated simultaneously. All the equations are specified in double-log form. Aggregate regional/seasonal production and production weighted prices are derived from relevant state level data from the fall of 1975 to the fall of 1987 (National Potato Council). The parameter estimates are interpreted as price flexibilities which represent the percentage change in the state level price in a given season/region as a result of a one percent change in any of the explanatory variables.

Statistical Results

Table 1 provides the results of these regressions. Most of our initial hypotheses are supported. Regional fall potato prices are significantly affected by own-production and production in other fall producing regions. Central fall production has a larger effect on eastern fall markets than does western production. It is likely that the central fall production is destined for markets more closely related to the eastern fall markets than are the western potatoes. For example, the average proportion of central and of eastern fall production destined for processing is about 30 percent, while more than 60 percent of western fall production goes to processors (National Potato Council).

Significant and negative own-production effects on prices in minor seasons are found only in the spring and summer. Winter production is so small relative to the rest of the market that its impact on even its own price is not statistically significant. The results pertaining to the temporal aspect of the potato markets indicate that prices for potatoes in the winter are positively correlated with the price for fall potatoes in the eastern region. If previous fall prices are high, winter acreage will likely increase, but the increased production is so small relative to the rest of the market that it does not depress prices in the winter. So, what we are likely observing is a high, positive correlation between winter production and other seasonal prices and not a causal effect. Spring and summer production are large enough, however, that there is a significant and negative own-production effect in these seasons. In addition, central fall production has a significant negative effect on the spring potato price.

Impacts of the Increases in 1990 Fall Potato Acreage

Using the results from Table 1, we now turn to the question of the regional and seasonal impacts of the 1990 fall acreage increases. To make predictions for each region and season, we assume that the fall producing regions experienced "normal" growing seasons in 1990. That is, we multiply the acreage changes by five-year average regional yields to estimate 1990 fall production

Table 1

Price Response Model, Regression Results

Explanatory Variable		DEPENDENT VARIABLE Prices					
		East	Central	West	Winter	Spring	Summer
QUANTITY	Fall East	-1.21 (2.09)	-.53 (-1.39)	-.63 (-1.78)			
	Fall Central	-2.85 (-2.74)	-1.61 (-2.39)	-.26 (-.42)			
	Fall Western	.56 (.35)	-1.09 (-1.05)	-2.12 (-2.20)			
	Winter				-.17 (-.72)		
	Spring					-1.26 (-4.22)	
	Summer						-3.13 (-1.99)
LAGGED PRICE	Fall East				.73 (1.65)	.94 (2.41)	2.22 (1.34)
	Fall Central				-.67 (-1.03)	-1.01 (-2.20)	-3.24 (-1.12)
	Fall Western				.40 (.76)	.87 (1.84)	2.63 (1.22)
	Winter					.11 (.21)	-1.59 (-.96)
	Spring						.03 (.03)
Constant		39.62 (3.52)	38.57 (5.30)	37.13 (5.51)	3.17 (1.73)	13.05 (3.77)	34.70 (2.26)
R-square		0.80	0.89	0.84	0.40	0.71	0.44

t-statistics are in parentheses.

levels. We then use the percentage change in production from 1989 levels in each fall region to make predictions based on the estimated price flexibilities from Table 1.

The predicted percentage changes in regional and seasonal average prices are shown in Figure 1. The greatest changes occur in the western fall region, an acreage increase of about 56,500 acres (9%) and a price decrease of about 20 percent. The central fall region experiences a 13 percent price decrease while increasing acreage by only about two percent. Effects of expansion in the fall producing regions' acreage has different effects on the subsequent seasons' prices. Spring price is predicted to fall by about 5.2 percent, and summer price to decrease about 12 percent, while there is no predicted effect on winter price.

Eastern fall producers appear to be somewhat insulated from the effects of major acreage changes in the west. The central fall production region's producers, however experience a larger decline in total revenue largely as a result of the actions of western fall producers. It is somewhat surprising that the changes in western fall production are estimated to have little or no effect on the other fall regions' prices, despite its large share of the market. As previously mentioned, however, western potatoes are predominantly for processing and may not compete directly with the more heavily tablestock production of the other regions.

Buyers of potatoes are likely to look more toward western and central fall sellers when making their discretionary purchases of fall, 1990 potatoes. They can expect additional savings through the summer of 1991.

Conclusions

The results of this study indicate that there are significant spatial and temporal price linkages within the U.S. potato market. The relative magnitudes of the linkages are, however, quite distinct across time and space, so that a formal measure of them is necessary for prediction purposes. When applied to the 1990 fall potato acreage changes, these measures indicate significantly different effects on potato prices across regions and seasons. These predicted 1990-91 price changes could be either mitigated or exaccrbated by final fall harvested acreage and yields, but they do provide a preliminary set of predictions useful for short term buying and selling strategies. The price flexibilities reported in Table 1 can be used in future marketing seasons to develop preliminary price predictions from announced planting intentions or planted acreage statistics as soon as they are published. This information should be useful for both buyers and sellers in making intra-season decisions.

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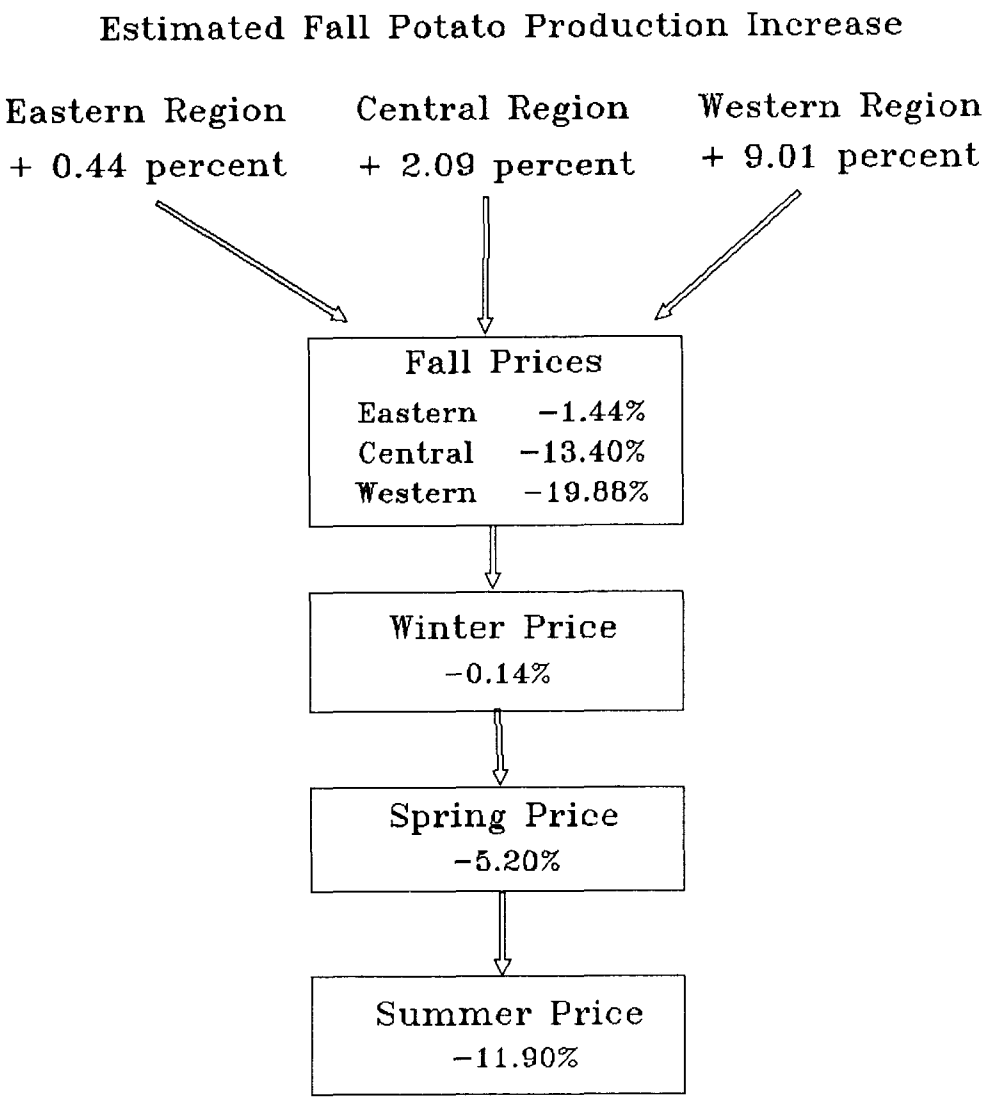

Figure 1: Estimated Price Effects from Fall 1990 Increased Production