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Submitted Article

Crop Prices, Agricultural Revenues, and the Rural Economy[1]

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Abstract *Policy makers in the United States often justify agricultural subsidies by stressing that agriculture is the engine of the rural economy. We use the increase in crop prices in the late 2000s to estimate the marginal effect of increased agricultural revenues on local economies in the U.S. Heartland. We find that $1 more in crop revenue generated 64¢ in personal income, with most going to farm proprietors and workers (59%) or nonfarmers who own farm assets (36%). The evidence suggests a weak link between revenues and nonfarm income or employment, or on population. Cuts to agricultural subsidies are therefore likely to have little effect on the broader rural economy in regions like the Heartland.*

Key words: Agriculture, Crop Prices, Rural Economy.

JEL codes: O13, J43.

Introduction

From 2000 to 2011 the combined annual payments from major U.S. federal farm programs (excluding crop insurance premium subsidies) ranged between $10–25 billion dollars per year (USDA-ERS 2014). Policy makers often justify these subsidies by stressing that agriculture is the engine of the rural economy. But is the relationship between agriculture and the rural economy strong enough to serve as a pillar of justification for agricultural subsidies?

Agricultural and regional economists assert that the U.S. rural economy is no longer a predominantly farm-based economy, emphasizing the diversity of rural economies and the growth of rural-urban linkages (Irwin et al. 2010; Castle, Wu, and Weber 2011). This assertion is well-founded: U.S agriculture dramatically reduced its use of labor in the 20th century as horses gave way

[1] *The views expressed here are those of the authors and do not represent the views of the USDA or the Economic Research Service.*

to tractors (and then bigger tractors) and favorable wages in other sectors motivated people to leave the farm (Kislev and Peterson 1982). Over the 20th century, the share of the workforce employed in agriculture declined from 41% to less than 2%, and production became concentrated on fewer, larger, and more capital intensive farms (Dimitri, Effland, and Conklin 2005).

Surprisingly, a search through economics and regional science journals from the last 25 years yields few empirical articles to assess statements about agriculture and its link to the broader rural economy—statements that are often made in discussions of the merits of agricultural support programs.[2] We present fresh empirical analysis of the link by using the increase in crop prices in the late 2000s to estimate the effect of greater agricultural revenues on local income, employment, and population in counties in the U.S. Heartland. The increase in crop prices over the decade—caused in part by a more than six-fold increase in ethanol production from 2000 to 2009 (Wallander, Claasen, and Nickerson 2011) —presents a promising empirical opportunity. Corn prices were 74% higher from 2006–2010 period compared to the prior five-year period; soybean prices were 65% higher. The change in agricultural operating margins in the Heartland reflected the price increases: from 2005–2010 the value of production less operating costs per acre for both crops tripled (USDA-ERS 2012a).

Using data from the USDA Soil Survey Geographic Database, we exploit variations across counties in endowments of agriculturally productive land as an instrument for changes in agricultural revenue. Because the change in revenues from higher crop prices is highly correlated with the exogenously determined local endowment of productive land, the instrument captures the revenue increases associated with higher crop prices as opposed to other sources of change such as using more fertilizer, planting a different crop mix, or suburban sprawl taking land out of farming.

Our empirical approach contrasts with much previous work that uses regional or national input-output models to quantify the relationship between agriculture and the broader economy (Otto 1986; Edmondson et al. 1996; Edmondson 2008; Paggi et al. 2011). Though comprehensive in their treatment of the entire economy, input-output models rest heavily on often untested assumptions about relationships between sectors, and comparisons with empirical studies suggest that the models often overstate local economic effects (Kilkenny and Edmiston 2004; Fox and Murray 2004; Partridge 2009; Weber 2012).

The Implications of Higher Crop Prices: Several Observations

The rural economy and the agricultural sector in the United States have changed substantially in the last 50 years, and the changes have affected the link between the two. In 1950, 42% of the rural population lived on farms;

[2]There are many studies of the off-farm labor supply of farm households and farming returns and land values but we consider studies linking agriculture to nonfarm outcomes. There is a small body of empirical literature on aspects of the link between agriculture and the local economy. Examples include studying where farmers spend money (Foltz and Zeuli 2005; Lambert, Wojan, and Sullivan 2009); the role of export sectors (including agriculture) on rural growth (Kilkenny and Partridge 2009); the local employment effects of large-scale hog farms (Sneeringer and Hertz 2013); and the local income effects of community-focused agriculture (Brown et al 2013).

by 2000 that number was 5%.[3] Innovation in farming equipment and a capital to labor cost ratio favorable to mechanization have allowed one farmer to cover more and more acres. According to Bechdol, Gray, and Gloy (2010), the technology of the 1970s allowed one farmer to plant 40 acres; in 2010 a farmer could plant 945 acres. The same is true in parts of Brazil, Argentina, and the Ukraine, and may become increasingly true in other emerging market countries.

The capital intensification of crop agriculture affects how higher crop prices ripple through the rural economy. Because row-crop agriculture in the 2000s involves few people, changes in crop prices most likely affect the rural economy by affecting returns to assets employed in production, not through employing more labor. This fits descriptive statistics from the Heartland: from 2005 to 2010, real cash labor costs for the average farm only increased by 4%, as did the average weekly real wage for people employed in crop production establishments in key Heartland states (Illinois, Indiana, and Iowa). This suggests that the small increase in cash labor costs reflects growth in wages, not employment.

The returns to fixed or semi-fixed farm assets, in contrast, should increase with crop prices. The most fundamental farm asset—cultivable land—is essentially fixed. From 1945 to 1997, the number of acres of cropland increased by less than 1% (Nickerson, Ebel, Borchers, and Carriazo 2011). Even with the strong price increases in the late 2000s, acres harvested decreased slightly from 2000 to 2009 (Wallander, Claasen, and Nickerson 2011). As crop prices increased, greater demand caused land rental rates to increase. The Agricultural Resource Management survey reveals that from 2005 to 2010 real cash rental rates paid by the average Heartland farmer increased by 22%. Similarly, the average farm's land rental expense, which gives more weight to farms renting more land, increased by 30% (table 1).

Another asset whose returns may increase with higher crop prices is agricultural machinery such as tractors, planters, and combines. Without an increase in the land base or increased double cropping, a farmer has no need to buy another tractor. However, the increase in the amount of capital purchases that farms can declare as an expense in the year purchased expanded in the late 2000s (Williamson, Durst, and Farrigan 2013). Tax incentives combined with high incomes encouraged farmers to buy new machinery. At the same time, tractor prices appear to have increased: from 2005 to 2010 the nationwide price of a large, two-wheel-drive tractor increased by 16%, some of which may reflect greater technology embodied in newer tractors, in addition to higher prices (table 1). Higher machinery prices in turn increase the cost of replacing existing machinery, thereby raising the implicit return that a farmer earns by renting a tractor to himself, or the explicit return earned from renting it to someone else. From 2005 to 2010 the cost of hiring someone to use their machinery to plant and harvest an acre of corn in Iowa increased by 13% (table 1).

Who Gains from Higher Crop Prices? A Conceptual Framework

The richest conceptual models linking agriculture and the rural economy have their roots in the international development literature and pertain to

[3]*Accessed at the American Demographic History Chartbook at http://www.demographicchartbook.com/Chartbook/ (accessed December 9, 2014).*

Table 1 Higher Prices and Costs for Land and Farm Capital

Input	2005	2010	Percentage increase
Prices			
Cash rents for land (per acre)	171	208	22%
Custom farming (per acre of corn)	90	102	13%
Tractor purchase price (2 wheel drive, 190-220 HP)	140,681	163,000	16%
Wages (per week)	568	592	4%
Costs for the Average Heartland Farm			
Rent and lease payments (for land)	14,029	18,249	30%
Custom work	2,426	2,001	−18%
Depreciation expense	11,943	14,914	25%
Cash labor costs	5,734	5,948	4%

Note: Monetary amounts are converted to 2010 dollars using the Consumer Price Index-U series. Cash rents are calculated from the Agricultural Resource Management Survey. Custom farming costs are for Iowa and are from the National Agricultural Statistics Service (NASS) Annual Statistics Bulletin for the state: http://www.nass.usda.gov/Statistics_by_State/Iowa/Publications/Annual_Statistical_Bulletin/2010/index.asp. Tractor and fertilizer prices are from the NASS prices paid survey, available at http://www.nass.usda.gov/Quick_Stats/. Weekly wages are from the Quarterly Census of Employment and Wages and are for people employed in crop production in Illinois, Indiana, or Iowa. The wage for each state is weighted by its share of total crop production employment in the three states. The costs for the average Heartland Farm are drawn from tailored reports from the ARMS Farm Financial and Crop Production Practices database: http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices.aspx#startForm.

an agricultural sector that supports the livelihoods of much of the rural population (Rao 1986; Ray 1998; Foster and Rosenzweig 2004) or a U.S. rural economy when the country still had a "farm problem" of excess labor on farms (Gisser 1965). Given their context, the models emphasize labor market issues such as wage appreciation and migration between rural and urban areas. For the U.S. Heartland, where farms use large equipment and few people to produce row crops, this emphasis is misplaced. We therefore approach the topic differently by using a theoretical framework and empirical focus that highlight how greater revenues primarily increase the incomes of owners of land and farm capital.

We describe a local farm sector and its context, including some of the stylized facts discussed above to more formally illustrate who in the local economy gains from higher crop prices. Consider a representative farmer who uses land (t), farm capital (k), labor (l), and a composite variable input that we refer to as fertilizer. Farm capital can be understood broadly to include tractors and farming expertise. The weakly concave function f represents the technology used to combine the inputs to produce a composite crop. Although farmers almost certainly face increasing returns to scale at some levels, the small number of massive crop farms in the United States suggests that eventually farmers face declining returns as they expand.

We abstract away from land use changes from suburban sprawl or other sources and assume that land available to grow crops is fixed. The assumption has strong empirical support: as previously mentioned, acres of cropland hardly changed over half a century (Nickerson, Ebel, Borchers, and Carriazo 2011). And to be clear, assuming the fixity of land is distinct from assuming no changes in crop mix. Our empirical approach deals with this endogenous response, but our theoretical discussion abstracts away from specific crops.

The world market sets the crop, farm capital, and fertilizer price. Because of competitive land markets, the rental price equals the marginal value product of land. The local market determines the wage paid to labor, and because the farm sector is a small part of the rural economy, marginal changes in farm labor demand do not affect the wage.[4]

The representative farmer maximizes profits by choosing capital, labor, and fertilizer such that their price equals their marginal value product. In equilibrium, the farmer earns the market wage on his labor and a return (θ) on land or farm capital assets that he owns. The rate of return θ is such that it makes the farmer indifferent between holding his wealth in farm or nonfarm assets.

Suppose that the crop price increases from a combination of rising global demand and a change in policy (e.g., the ethanol mandate). Because land is the most fixed input, its price—the land rental price (r_t) —will increase the most. How much a percentage change in the crop price (p_c) translates into a higher land rental price is given by $r_{t,low}/r_{t,high} = p_{c,low}/p_{c,high} \cdot f'_{t,low}/f'_{t,high}$. The equality holds because land receives a rental payment equal to its marginal value product ($r_t = p_c f'_t$) in both the high and low price scenarios. The less the marginal product of land (f'_t) changes from the low to high price scenario, the more that a percentage change in the crop price will cause a similar percentage change in the land rental price. In the extreme, $f'_{t,low} = f'_{t,high}$, in which case $r_{t,low}/r_{t,high} = p_{c,low}/p_{c,high}$.

We also consider an increase in farm capital and fertilizer prices. The price of human capital specific to farming increases because it is largely fixed in the short term (it takes time to learn how to farm). The price of physical capital and fertilizer increase because the global industries producing them experience higher costs as they expand. In contrast, the crop price has no effect on the wage because of the small role of farming in the local labor market. The use of farm capital and fertilizer increases as long as the percentage increase in their prices is less than the percentage increase in the land rental price. By assumption, this is true for labor, and so its use increases.

Income Gains from Higher Crop Prices

Assuming that fertilizer and farm capital are produced outside the local economy, the primary local income effects are from the following: farmers earning higher returns to land and farm capital; greater use of labor by the farm; and landlords (who are not farmers themselves) earning higher returns to land. We refer to the three effects as a farm proprietor income effect, a farm wage and salary effect, and a landlord income effect, defined as:

$$\Delta \textit{ Farm proprietor income} = \Delta r_t t_f + \Delta r_k k_f, \tag{1a}$$

$$\Delta \textit{ Farm wage and salary income} = w\Delta l, \text{ and} \tag{1b}$$

$$\Delta \textit{ Landlord income} = \Delta r_t t_{ll}, \tag{1c}$$

[4] *There was a small increase in wages for labor employed in crop production (table 1), which does not appear to have influenced wages in the general economy. The average wage in Illinois, Indiana, and Iowa (weighted by total employment) increased by less than 1% from 2005 to 2010.*

where Δl is the change in optimal labor use and t_{ll} is the land owned by landlords who are not farmers.

The farmer earns more income from higher rental prices, or put differently, from earning a return of θ on wealth created by land and farm capital appreciation. The income gain from land or farm capital can be written as the change in the rental price (Δr_t or Δr_k) multiplied by the total amount initially owned (t_f acres and k_f units of farm capital, where the subscript stands for farmer). Because the purchase price equals the discounted price of renting land, we have $\Delta r_t t_f = \theta \Delta p_t t_f$ and $\Delta r_k k_f = \theta \Delta p_k k_f$. Whether the farmer bought more land or machinery in response to the higher crop price has no effect on his income. Presumably he would do so by liquidating assets earning θ elsewhere, which is what he will earn on new investments in land or capital.

The second income effect is an increase in farm wage and salary income from greater total labor use. After the farmer and market prices have responded to the higher crop price, all factors of production are paid their marginal value product. Assuming that a farmer's wage could be separated into a payment for labor and a rental payment for his skills and knowledge, a farmer owning no land or farm capital would only earn a wage for his labor. More labor used, either from the farmer or a hired person, generates more labor income. The third income effect is from the higher returns earned by landlords on the land they owned prior to the price increase. The landlord, like the farmer, receives higher rents for land.

The Effects of Higher Revenues: Empirical Strategy, Identification, and Estimation

The terms in (1a), such as the increase in the rental price of land or farm capital, determine how \$1 more in revenue from a higher crop price translates into farm proprietor income. We use β_0 to reflect their combined effects. If the proprietor does not pay himself an explicit wage, β_0 will also reflect any increase in payments to the proprietor's labor. Similarly, we use β_1 to reflect the increase in wage and salary payments to labor per dollar of revenue. Adding error terms, we write the farm proprietor and farm wage and salary income effects as follows:

$$\Delta\ \mathit{Farm\ proprietor\ income} = \alpha_0 + \beta_0 \Delta \mathit{Revenue} + \varepsilon_0, \tag{2a}$$

$$\Delta\ \mathit{Farm\ wage\ and\ salary\ income} = \alpha_1 + \beta_1 \Delta \mathit{Revenue} + \varepsilon_1. \tag{2b}$$

We do not directly observe the change in landlord income. Instead, we observe the change in income from rents, interest, and dividends, which we refer to as property income. The following equation

$$\Delta\ \mathit{Property\ income} = \alpha_2 + \beta_2 \Delta \mathit{Revenue} + \varepsilon_2, \tag{2c}$$

reflects how \$1 in agricultural revenue translates into property income, which in addition to land rental income received by non-farmers, also captures dividends paid by incorporated businesses and rental income from nonfarm properties.

Finally, we capture the potential effects on nonfarm labor earnings or nonfarm proprietor income by:

$$\Delta \textit{ Nonfarm nonproperty income} = \alpha_3 + \beta_3 \Delta \textit{Revenue} + \varepsilon_3. \tag{2d}$$

Because total personal income equals the sum of farm proprietor income, farm wage and salary income, property income, and nonfarm non-property income, the sum of the βs gives the total income created by a $1 increase in agricultural revenues.

There are two challenges to estimating equations (2a)–(2d). First, counties abundant in farmland have long experienced secular trends in migration and economic growth distinct from other counties (Johnson 2003; Johnson and Cromartie 2006). Using *Land* to represent the endowment of agriculturally suitable land in the county and y to represent one of the four outcomes from (2a)–(2d), the equations are more appropriately written as

$$\Delta y = \alpha + \beta \Delta \textit{Revenue} + (\rho \textit{Land} + \varepsilon). \tag{3}$$

Because acres of cropland and acres of agriculturally suitable land are highly correlated, the revenue change will be linearly related to the composite error term $\rho \textit{Land} + \varepsilon$, precluding identification of β. Differencing with the change in revenues from the prior period, however, addresses the problem if the land endowment is fixed and the coefficient ρ is time invariant. In this case, the endowment of agriculturally suitable land in the county is correlated with the error in a first differenced equation (i.e., $\Delta y = y_{t+2} - y_{t+1}$) but not the error in the double-differenced equation ($(y_{t+2} - y_{t+1}) - (y_{t+1} - y_t)$).

The second challenge in estimating β is that changes in revenues are potentially correlated with an endogenous supply response related to local economic conditions. Moreover, changes in revenues associated with livestock operations were offset by higher feed costs and in general did not lead to greater farm incomes. To address both issues we instrument the change in revenues using the acres of high-quality land (acres in land capability classes I and II, described in the data section to follow). Using land endowments as an instrument for the (double differenced) change in revenues avoids capturing an endogenous supply response if farmers in counties with larger land endowments did not systematically increase per-acre fertilizer use or expand on the extensive margin (or change crop mix and so forth) more than farmers in areas with a smaller endowment. Although not linked to an endogenous supply response, the endowment of high-quality land will be strongly correlated with the change in revenues because areas with a larger high-quality land endowment will have more acres in production and therefore benefit more from higher crop prices. And because the amount of high-quality land is correlated with crop production, it primarily captures the change in revenues associated with higher crop prices, which translated into higher farm income, as opposed to changes in livestock revenues, which did not.

Estimation

Instead of using annual variations in crop revenues, our empirical approach exploits the shift from relatively low crop prices in the early 2000s to high prices in the second half of the 2000s. We specify 2000–2005 as the first period and 2005–2010 as the second period. Following a long period of modest or no growth, corn and soybean prices increased substantially in 2007 and remained high through 2010.

Adding control variables and crop reporting district effects provides our core county-level empirical model

$$\Delta y_{i,10-05,05-00} = \alpha + \beta \Delta R_{i,10-05,05-00} + \theta \boldsymbol{X_i} + \eta_{crd(i)} + \Delta \varepsilon_{i,10-05,05-00}, \quad (4)$$

where $\Delta y_{i,10-05,05-00} = \Delta y_{i,10-05} - \Delta y_{i,05-00}$, and similarly for the change in revenue. The vector $\boldsymbol{X}$ includes control variables whose values correspond to 1999 or, in the case of two variables, from the 2000 Census. We include the county's population density, the share of the population with at least a bachelor's degree, the share of the population between the ages of 25 to 64, and per capita employment in manufacturing, construction, and retail, all separately. We also include two spatial variables—the average acres of high-quality land in contiguous counties and an indicator for the county's rural-urban continuum code. The rural-urban continuum codes are based on the county's urban population and adjacency to a metropolitan county. The $\eta_{crd(i)}$ accounts for any unobservable characteristics correlated with $\Delta y_{i,10-05,05-00}$ and common to counties in the same crop reporting district. The districts group agriculturally similar and geographically contiguous counties in the same state. As such, they are a more geographically precise than state dummy variables and therefore better help to control for spatially correlated unobservable variables (in the Heartland there are roughly 10 counties per district).

We divide the dependent variables by population in 1999 to reduce skewness. We do the same for the change in revenues and can therefore interpret the coefficient β as the number of dollars or jobs associated with an extra dollar in revenue. For a similar reason, the average endowment of quality land in contiguous counties is also normalized by population.

We use equation (4) to estimate the effect of agricultural revenues on total personal income, which we then break into farm proprietor income, farm wage and salary income, property income, and nonfarm non-property income to estimate β_0, β_1, β_2, and β_3. For employment, we examine total employment, which we break into farm employment and nonfarm employment. This allows us to estimate a farm-nonfarm employment multiplier. Finally, we look at changes in population to see if greater agricultural revenues attract or retain people in rural areas, many of whom have experienced prolonged periods of depopulation in the past 50 years.

In all cases, we instrument the change in agricultural revenues with the county's endowment of high-quality land. A first-stage regression confirms that the number of acres of high-quality land is strongly correlated with the change in revenue from 2005 to 2010 relative to the change from 2000 to 2005. Each acre was associated with a \$130 dollar increase in agricultural revenues (s.e. 24). The corresponding F-statistic for the statistical significance of the coefficient on high-quality land (30.1) demonstrates is strength as an instrument for the change in agricultural revenues.

The large increases in corn and soybean prices are the primary reason why each acre was associated with more revenue in 2010 than in 2005, but another contributor was modest growth in per acre yields. Higher yields in 2010 than in 2005 imply an increase in the relationship between acreage and gross agricultural revenues. This increase stems from sector-wide yield growth, and is different from higher yields caused by farmers in some areas responding to prices by increasing input use, which we do not capture as long as such responses are uncorrelated with county land endowments.

Data and Sample Counties

We construct county endowments of high-quality land using the Soil Survey Geographic Database from the Natural Resources Conservation Service, which measures land attributes at a fine geographic level (as small as several acres), with one attribute being the parcel's USDA Land Capability Class.[5] There are eight Land Capability Classes based on the land's limitations for agriculture. We define high-quality land as land in Class I or II, which is land well-suited for intensive crop production. Acres of high-quality land match well with acres harvested: 51% of the land in the average sample county is high quality; the 1997 and 2002 Censuses of Agriculture indicate that 54% of the average sample county was harvested.

The key independent variable, agricultural revenues, and all of the outcome variables come from the Local Area Personal Income and Employment estimates of the Bureau of Economic Analysis. We define agricultural revenues as the sum of the Bureau's estimate of cash receipts from marketing, plus its "other income" variable. The Bureau of Economic Analysis calculates marketing receipts using annual state and county-level information from the USDA. Where only state-level data are available, Census of Agriculture data on cash receipts by commodity are used to allocate state totals to counties. The "other income" variable includes payments from all the major federal farm programs (direct payments, counter-cyclical payments, loan deficiency payments, crop insurance indemnities, etc.), all of which add to farm revenue and are therefore included in revenues instead of entering our model as a separate independent variable.

Total personal income as estimated by the Bureau of Economic Analysis is a comprehensive measure of income received by a county's residents. The bureau's estimate of farm proprietor income captures income going to sole-proprietor and partnership farms. This estimate excludes wages and salaries that the farm pays to the farm proprietor, and therefore largely reflects the income that farmers receive from renting land and farm capital to themselves. In addition to wages or salaries paid to the proprietor, farm wage and salary income includes wages paid to hired workers. For our measure of property income earned by county residents we use the bureau's dividend, interest, and rental income as landlord income. This excludes the net rents to farm proprietors, so it does not overlap with farm income. As mentioned previously, property income captures more than the effect of higher crop prices on landlord income; it includes all passive income such as rental income from nonfarm properties and dividend income received by shareholders of corporate farms. The last category of income is nonfarm non-property income, which we calculate by subtracting farm and property income from total personal income. Doing so leaves transfer income like social security payments, nonfarm self-employment income, and nonfarm wage and salary income.

On the employment side, we use the Bureau of Economic Analysis estimate of total employment, which is then separated into farm and nonfarm

[5] *For more information on the SSURGO Database, please visit http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627 (accessed December 9, 2014).*

Table 2 Definitions of Key Variables

Variable	Description
Agricultural revenues	Farm gross receipts, including Federal farm program payments and crop insurance indemnities
Income	
Total personal income	Income from all sources received by county residents
Farm proprietor income	Income earned by farm proprietorships and partnerships
Farm wage and salary income	Wages and salaries paid to farm workers, including to the farm proprietor
Property income	Property income, including interest, dividend, and rental payments
Nonfarm nonproperty income	Income to the nonfarm self-employed, nonfarm wage and salary workers, and transfer income.
Employment and population	
Total employment	Wage and salary jobs, sole proprietorships, and general partners, by place of work
Farm employment	Farm self-employment and wage and salary employment
Nonfarm employment	Nonfarm self-employment and wage and salary employment
Population	Census Bureau's annual midyear population estimate

Note: Definitions are drawn heavily from the Bureau of Economic Analysis' Local Area Personal Income and Employment Methodology document: http://www.bea.gov/regional/pdf/lapi2011.pdf.

employment. Farm employment includes farm self-employment and wage and salary employment. Lastly, population is the Census Bureau's mid-year population estimate. We provide the definitions of all outcome variables in table 2, and descriptive statistics for all variables used in the analysis are shown in table 3.

Study Region

Our initial sample includes all the counties in the Heartland region as defined by the USDA\Economic Research Service. Given its favorable climate and soils, corn and soybeans dominate the region's agricultural landscape, and it accounts for more than half of the cash grains produced in the country (Hoppe and Banker 2010). To focus on more rural counties we exclude counties in metropolitan areas with 250,000 or more in population, which corresponds to counties with a rural urban continuum code of 1 or 2. We also drop two counties missing agricultural revenue data. This leaves 427 Heartland counties, which are the darkest colored in figure 1.

Looking at sample descriptive statistics, we see why some may be skeptical of a strong link between the farm economy and the rural economy. In 2005, farm income (farm proprietor income plus farm wage and salary income) accounted for about 3% of total income; farm employment accounted for about 5% of total employment.

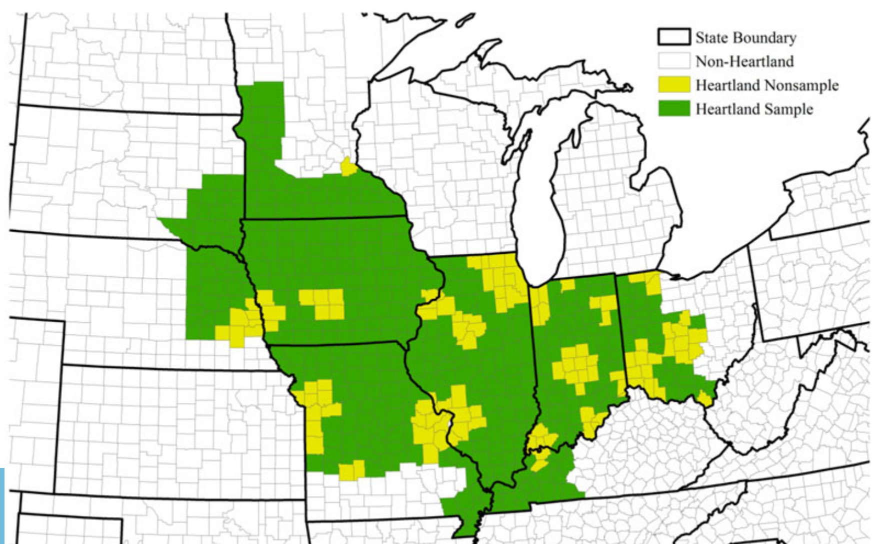
Relative to the change in the prior five years, real agricultural revenues in the average sample county increased by $29.8 million from 2005 to 2010.

Table 3 Sample Descriptive Statistics

	Mean	S.D.	Median
Doubled Differenced Variables (2010 − 2005) – (2005 − 2000)			
Agricultural revenue	29,808	34,079	28,203
Total income	36,475	139,318	25,855
Farm proprietor income	−1,472	26,229	−2,008
Farm labor income	747	1,788	404
Property income	59,349	62,290	43,189
Nonfarm nonproperty income	−22,148	121,516	−6,124
Total employment	−188	2,031	64
Farm employment	185	93	164
Nonfarm employment	−372	2,040	−113
Population	153	862	67
Continuous Control Variables			
Land (1,000 acres)	179	111	165
Population density (people/sq. mile)	57	57	37
Share bachelor's degree or more	0.10	0.04	0.09
Pop. ages 25–64	0.49	0.03	0.50
Share emp. in manufacturing	0.09	0.07	0.08
Share emp. in construction	0.03	0.01	0.03
Share emp. in retail	0.09	0.03	0.08
Farm and Total Income and Employment, 2005			
Farm income	30,974	25,141	25,131
Total income	936,736	1,115,407	571,158
Farm employment	843	352	795
Total employment	16,968	21,677	9,811

Note: All but three variables are from the Bureau of Economic Analysis Local Area Personal Income and Employment Estimates program. Acres of land in Land Capability Class I or II (Land) is calculated from shape files as part of the USDA Soil Survey Geographic Database (SSURGO). The share of the population with a bachelor's degree or higher and the population aged 25–64 are based on the 2000 Census. Monetary amounts are in 2010 dollars.

Figure 1 Heartland Counties Used in the Empirics



The variation across counties in the change in farm income was large and on average the increase in farm income from 2005 to 2010 was similar to the increase over the prior five years. The lack of a larger increase in the 2005–2010 period reflects lower incomes for livestock farms, which faced higher feed costs. As mentioned previously, revenue increases from higher crop prices are nonetheless associated with greater endowments of high-quality land, which is how we identify their effects in our regressions.

Results

We find that higher agricultural revenues from higher crop prices led to greater personal income by increasing farm and property income. One dollar more in revenue increased personal income by 64¢ (table 4). This estimate is consistent with Brown et al. (2013) who examined the effect of community-focused agriculture and found that a $1 increase in farm revenues between 2002 and 2007 led to a 48¢ increase in personal income for Midwestern counties.[6] Of the total income effect, farm proprietor income accounted for 38¢, farm wage and salary income accounted for 2¢, and property income accounted for 23¢. The estimated effect on nonfarm nonproperty income was very small (2¢) and statistically insignificant. Even the upper end of the 95% confidence interval of the point estimate is small (32¢). Combined with the farm income effect, the upper bound estimate implies a farm-nonfarm income multiplier of just 0.51 (=32/63).

We also find that farm and property income were positively correlated with the average endowment of high-quality land in contiguous counties. The average sample county shared a boundary with six counties, so adding one acre of high-quality land to a contiguous county increases the average endowment of contiguous counties by 1/6. The estimates therefore imply that adding one acre of high-quality land in a contiguous county would increase farm proprietor income in the average sample county by $3.70 (=22/6) and property income by $4.10 (=25/6). Because each acre was associated with a $130 increase in agricultural revenue, the estimates imply that $1 more in revenue in a contiguous county was associated with roughly 3¢ more in farm proprietor income and 3¢ in property income.

The effect of revenues in contiguous counties on farm proprietor income may be because larger farms, which tend to be more profitable, are more common in multi-county regions that are abundant in agriculturally-suitable land. The effect on property income may reflect the greater profitability of farming in such areas or more intense competition for land, both of which would increase the land rental price. Alternatively, county residents may be more likely to own farmland if it is plentiful in contiguous counties.

It may seem surprising that the effect on property income accounts for 36% (=0.23/0.64) of the total income effect. As highlighted in the theoretical section and in previous work, the inelastic supply of land allows landowners to capture much of the greater income from crop prices (Floyd 1965). Taking the land that farmers rented from landlords who are not

[6]The difference between our estimate and Brown et al. (2013) is small when considered in light of other multipliers in the literature. Edmondson (2008), for example, finds that $1 more in agricultural exports lead to $2.65 in economic output and therefore $2.65 in income. This is orders of magnitude larger than our local income multiplier.

Table 4 Agricultural Revenues, Income, Employment, and Population

Covariates	Total personal income Coef/se	Farm proprietor income Coef/se	Farm labor income Coef/se	Property income Coef/se	Nonfarm nonproperty income Coef/se
Agricultural revenues	0.64***	0.38***	0.02***	0.23**	0.02
	(0.13)	(0.09)	(0.01)	(0.09)	(0.15)
High-quality land in contiguous counties	43.17	21.81**	−0.06	25.31**	−3.89
	(31.78)	(10.89)	(1.45)	(12.70)	(28.26)
Crop reporting district dummies	yes	yes	yes	yes	yes
Other controls included	yes	yes	yes	yes	yes
Observations	427	427	427	427	427

Covariates	Total employment Coef/se	Farm employment Coef/se	Nonfarm employment Coef/se	Population Coef/se
Agricultural revenues	2.83	1.39***	1.44	−0.58
	(2.00)	(0.46)	(1.95)	(1.04)
High-quality land in contiguous counties	−0.58	−0.06	−0.51	−0.16
	(0.50)	(0.06)	(0.50)	(0.30)
Crop reporting district dummies	yes	yes	yes	yes
Other controls included	yes	yes	yes	yes
Observations	427	427	427	427

*Note: Asterisks *** indicate $p < 0.01$, ** indicate $p < 0.05$, and * indicates $p < 0.1$ The table summarizes the key results from 9 regressions (5 in the top half of the table and 4 in the bottom half). Each regression uses the same specification but a different outcome variable. Robust standard errors clustered at the crop reporting district are in parenthesis. The models are estimated using Two-Stage-Least-Squares where acres of high-quality land is used as an instrument for the change in agricultural revenues. The coefficients on agricultural revenues for the four components of personal income do not exactly sum to the total effect (0.64) because of rounding.*

farmers themselves, and assuming that all of it is cropland implies that in 1997 landlords owned 60% of the cropland in sample counties.[7] Moreover, much land is owned by landlords who live near the land that they own. The last USDA survey on the subject found that 70% of landlords (individuals or partnerships) that were not farmers lived within 25 miles of the land they rented out (USDA-NASS 1999).

We estimate that increases in farmland rental rates account for roughly three-quarters of the increase in property income. Real cash rents in the Heartland increased by $37 per acre from 2005 to 2010 (table 1). Assuming that 60% of cropland is owned by people who are not farmers implies that $22.20 (=$37 × 0.60) in greater rental income went to landlords who do not farm. Each acre of quality land increased agricultural revenues by $130, and property income by $29.90 (=$130 × 0.23). Thus, about three-quarters (22.20/29.90) of the property income effect is from higher land rents paid to landlords who are not farmers.

The other one-quarter of the increase may reflect greater dividend payments to shareholders of corporate farms, defined as farms filing taxes as a corporation. The 2010 Agricultural Resource Management Survey shows that corporate farms accounted for 12% of the value of crop production in the Heartland. Supposing that they experienced an income increase proportional to their value of crop production implies that the total farm income effect (corporate and non-corporate farms) would be 43¢ per dollar in revenue (=0.38/(1−0.12)), 5¢ higher than when only considering non-corporate farms. This suggests that corporate farm income accounts for 5¢ of the 23¢ in higher property income.

Employment and Population

Table 4 also shows that each $1 million in additional agricultural revenues increased total employment by 2.8 jobs, 1.4 of which were farm jobs (self-employed and hired). The estimates suggest a farm-nonfarm employment multiplier of around 2, but the total employment effect has a very large standard error and the estimated effect on nonfarm non-property income suggests no increase in nonfarm full-time equivalent jobs (the employment data combine full and part-time jobs). Moreover, we find no evidence of an effect on population. The upper bound of the 95% confidence interval for the population effect implies that each million dollars in agricultural revenues attracted about 1.5 people.

Does Double-differencing Matter?

Double-differencing the dependent variable to account for prior trends matters. A first-differenced model (2005–2010) with control variables at their 2004 values provides much smaller estimates of the income and employment effects compared to the double-differenced model (table 5). We expect this if agricultural counties experienced a prior trend of economic decline. The point estimate for the effect of an extra dollar of revenue on nonfarm nonproperty income is −0.12. For property income, the effect is

[7] *From the 1997 Census of Agriculture we calculate the total land rented from landlords who are not farmers as the total land in farms (owned + rented from others − rented to others), less the land owned by farms. The calculation avoids capturing land rented from one farmer to another. As long as the two farmers are in the same county, the transaction has a zero net effect on the total in farms.*

Table 5 Estimates of the Effect of Agricultural Revenues Using a First-differenced Model

Total personal income	**Farm proprietor income**	**Farm labor income**	**Property income**	**Nonfarm nonproperty income**
0.21*	0.26***	0.01**	0.06***	−0.12
(0.11)	(0.06)	(0.00)	(0.02)	(0.08)
Total employment	**Farm employment**	**Nonfarm employment**	**Population**	
−2.70***	0.01	−2.71***	−6.56***	
(1.01)	(0.15)	(0.97)	(1.34)	

*Note: Asterisks *** indicate $p < 0.01$, ** indicate $p < 0.05$, and * indicate $p < 0.1$ Robust standard errors clustered at the crop reporting district are in parenthesis. The coefficient and standard error estimates are from models with the same covariates as the regressions in tables 5 and 6. The difference is that the outcome variables and the change in agricultural revenues are defined as the change from 2005 to 2010 only. Also, the 2004 values are used for control variables not from the 2000 Census.*

positive but much smaller than the double-differenced estimate (0.06 compared with 0.24). Differencing had the smallest effect on farm income, which only declined from 0.38 to 0.26.

The employment and population effects in the first-differenced model are also substantially smaller, implying that counties abundant in quality land experienced worse employment trends prior to the high-price period compared to other counties. The model shows that for each $1 million in agricultural revenues there was no change in farm employment, a nonfarm employment loss of 2.7 jobs, and a population loss of 6.5 people.

Discussion

From 2005 to 2010 agricultural revenues in the average sample county increased by $56 million. The estimated marginal effects imply that the increase created $36 million in income to residents (=56 × 0.67), a 3.8% increase over the 2005 level. A 3.8% increase in total income for the average county is not surprising considering the dramatic increase in per acre margins for corn and soybeans over the study period. More intriguing is the evidence that all of the income went to people who operated farms, worked on farms, or owned property. For employment, our (statistically insignificant) point estimate implies that greater revenues increased total employment in the average county by about 1% (≈(56 × 2.8 jobs)/16,968 total jobs), with half of the increase coming from farm jobs.

The weak evidence of a positive effect on the nonfarm economy is consistent with Keskin and Hornbeck (2012), who study spillovers from agricultural development in the mid-20^{th} century in and around the Ogallala aquifer, which covers much of the U.S. Great Plains. These authors found that in 1950 agricultural growth from accessing the Ogallala only generated short-term positive spillover effects. With the dramatic decline in the share of the rural population living on farms, it is not surprising that increases in agricultural revenues have an even more subtle effect on the rural economy in the 2000s.

In their county-level study of the Corn Belt Region, Feng, Oppenheimer, and Schlenker (2012) suggest that changes in the agricultural economy could have large impacts on nonfarm employment. These authors study the relationship between weather shocks, crop yields, and migration from 1970–2009 period and find a large effect of yield shocks on migration. The authors explain the finding by suggesting that yield shocks affect agricultural revenues and profitability, which then have considerable effects on nonfarm employment. A change in revenues from weather and yield shocks (their study) should not have a fundamentally different local economic effect than changes in revenues from price shocks (our study). Our findings, which only concern the more recent part of their analysis, suggest that the link between agricultural revenues and nonfarm income and employment is weak.

Our estimates capture the local economic effects of higher crop prices and greater agricultural revenues. Moretti (2010) argues that local multipliers (e.g., the jobs created for each agricultural job) provide an upper-bound on national multipliers because labor supply is more elastic locally than nationally. However, using local revenues to estimate employment or income multipliers only captures the jobs and income created near where production occurs. County-level regressions using agricultural revenues as the key independent variable will not capture jobs created at the headquarters of Cargill or John Deere and their associated spillover effects.

Nonetheless, the estimated multipliers may to some extent still capture the effect of a farmer crossing a county boundary to buy inputs. Fertilizer dealers, for example, are most likely located in areas with high agricultural revenues. We do not control for the presence of agricultural service industries in the regressions. Assuming a positive employment effect on fertilizer dealers, any correlation between fertilizer dealer location and revenues would increase the estimate of the effect of agricultural revenues on nonfarm outcomes.

Conclusion

There are various arguments for public support of agriculture, including the goal of maintaining a stable and low-cost food supply. For our study region and period, we find little support for the argument that the farm economy merits public support because it is the engine of the rural economy. Considering rural counties in the U.S. Heartland, we find that the strength of the local farm economy—as measured by revenues—was not associated with growth in the nonfarm economy. A silver lining of the finding is that rural counties are on average resilient to the volatility characteristic of farming. The lower crop prices in 2013 and 2014 may therefore cause few ripples in the economies of rural counties.

Looking forward, we expect the link to further weaken. The macroeconomic conditions of the 2000s have encouraged farmers to buy more and larger tractors, planters, and combines: the price of capital to labor has decreased as interest rates have declined to historically low levels, and wages over most of the wage distribution have stagnated but not declined. At the same time, changes to tax policy allow farmers to declare as expenses more of their capital purchases in the year acquired, thus increasing tax savings from the purchases. Greater machinery investments will encourage farms to become larger and to use less labor, further weakening the link between crop agriculture and rural labor markets.

Trends in where owners of farmland live may further weaken the link between crop agriculture and local income. The share of the population of farmers that is near or older than retirement age is large. In 2011, 28% of the land in farms in the lower 48 states was on farms with a principal operator age 65 or older (USDA-ERS 2012b). It is therefore plausible that one-third of the land in farms will change hands in the next 15 years solely from farmers ageing. Anecdotally, it appears common for a farm household to transfer land to its children or other extended family members, many of whom have left the area. If the new absentee owners keep the land, income gains from higher crop prices will increasingly leave the county where the farm is located.

Our research, however, only considers one agriculturally important region. Greater agricultural revenues may have different effects in counties elsewhere, such as the more remote counties of the eastern plains where farming accounts for a larger share of the local economy. We also do not research the link between agribusinesses and the rural economy—to the extent that their location is uncorrelated with agricultural revenues. Future research could consider how expansion in such industries, perhaps for higher farm profits, affects local employment and income.

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