Crop Prices, Agricultural Revenues, and the Local Economy of the U.S. Heartland

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Abstract: Economists broadly recognize that the U.S. rural economy is no longer a farm economy, yet policy makers often justify support for agriculture by stressing the sector's importance to the rural economy. We use the historically high 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 in additional crop revenue generated 67 cents in local income, most of which went to farm proprietors and workers (58 percent) or nonfarmers who own farm assets (36 percent). There is no evidence of an effect on nonfarm income or employment, or on population.

Key words: Agriculture, Crop Revenues, Local Economy

JEL Codes: O13, J43

Introduction

U.S agriculture dramatically reduced its use of labor in the 20th century as horses gave way to tractors (and then bigger tractors) and favorable wages in other sectors motivated people to leave the farm (Kislev and Peterson 1982). Over the century the share of the workforce employed in agriculture declined from 41 percent to less than two percent, and production became concentrated on fewer, larger, and more capital intensive farms (Dimitri, Effland, and Conklin 2005). Economists recognize that the U.S. rural economy is no longer a farm economy, and emphasize the diversity of rural economies and the growth of rural-urban linkages (Irwin et al. 2010; Castle, Wu, and Weber 2011). Policy makers nonetheless often justify support for agriculture by emphasizing the sector's importance to the rural economy. Similarly, descriptive publications by the Federal Reserve attributed the better economic performance of rural America in the late 2000s in part to high crop prices (Henderson 2009; Testa 2011; Henderson and Akers 2012).

We use the historically high crop prices in the late 2000s and counties in the U.S. Heartland to estimate the relationship between agricultural revenues and local income, employment, and population. The increase in crop prices over the decade presents a promising empirical opportunity. Corn prices were 74 percent higher in the 2006-2010 period compared to the prior five year period; soybean prices were 65 percent higher (figure 1). The change in margins in the Heartland reflected the price increases: in real terms the value of production less operating costs per acre tripled from 2005 to 2010 for both crops (ERS-USDA, 2012a).

[Figure 1]

Using data from the USDA Soil Survey Geographic Database, we exploit variation 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 proportional to acreage harvested, the instrument isolates the revenue increases associated with higher as opposed to other sources of change such as using more fertilizer or suburban sprawl into farmland. It also avoids capturing the increase in revenue for livestock producers, which did not lead to higher profits because higher feed costs offset higher livestock prices.

Our empirical approach contrasts with much previous work, which used regional or national input-output models to quantify the relationship between agriculture and the broader economy (Otto, 1986; Edmundson et al, 1996; Edmundson, 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).

Our work is similar to empirical studies of the link between agriculture and the local economy. Examples include studying where farmers spend money (Foltz et al. 2002; 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). At the same time, we are unaware of academic studies in the last quarter-century that empirically estimate the relationship between higher agricultural revenues from higher crop prices and local economic outcomes in the contemporary U.S.

Furthermore, the richest conceptual models linking agriculture and the rural economy have their roots in the international development literature and have in mind an agricultural sector that supports the livelihoods of much of the rural population (Rao 1986; Ray 1998; Foster and Rosenzweig 2004). The models therefore 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, using a theoretical framework and empirical focus that highlight how greater revenues primarily increase the incomes of owners of land and farm capital.

We find that a dollar more in agricultural revenues in the county generated 67 cents in new income for residents. Of this, 39 cents went to farm proprietors, 24 cents to nonfarmers who own property, and 2 cents to hired workers. Beyond the 67 cents in income to county residents, the extra dollar in revenue also generated 6 cents for farm proprietors and nonfarmers who own of property and reside in contiguous counties. There is no evidence of an effect on nonfarm earnings, employment, or on population growth. The findings imply that more agricultural revenues in a given county, through good weather, expanding export markets, or higher crop prices, will have little effect on the county's labor market. Our work, however, does not estimate the state or national employment and income effects of higher crop prices.

Farm Responses to Higher Crop Prices: Some Observations

The U.S. rural economy has changed a lot in the last half century. In 1950, 42 percent of the rural population lived on farms. By 2000 the number was five percent.[2] 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, the same 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.

Because row-crop agriculture involves few people, changes in agricultural prices will most likely affect the rural economy by affecting returns to assets employed in production, most notably fixed assets like land. Increases in the price of an industry's good in most cases spurs the entry of new firms and the expansion of existing ones. Crop agriculture in the U.S. is different in that the supply of the industry's most fundamental input – cultivable land – is essentially fixed. From 1945 to 1997, the number of acres of cropland increased by less than one percent (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).

Higher crop prices encourage farms to buy or rent more land, which with a fixed amount of cropland, has increased land rental rates. Farmer responses to the Agricultural Resource Management survey reveal that from 2005 to 2010 real cash rental rates paid by Heartland farmers increased by 22 percent. Similarly, the average farm's land rental expense, which gives weight to farms renting more land, increased by 30 percent (table 2).

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[2] Accessed at the American Demographic History Chartbook at http://www.demographicchartbook.com/Chartbook/.

The higher price of land relative to other inputs may motivate farmers to use land more intensively. One way is through double cropping – harvesting two crops off the same land in the same year. A common double-cropping scenario is to plant winter wheat in the fall, harvest it in the spring, and then immediately plant soybeans. Wallander et al. (2011) found that double cropping increased by 16 percent from 2002 to 2007 nationally. However, it only increased by four percent in key Heartland states, which for the most part have a growing season too short for double-cropping.

The other 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 an increase in double cropping, a farmer has no need to buy another tractor. However, record cash incomes combined with changes in tax policy encouraged farmers to buy new equipment. In 2008 the maximum amount of capital purchases that farms can expense in the year purchased increased from $25,000 to $250,000, and in 2010 it increased to $500,000 (Williamson, Durst, and Farrigan, 2013). The changes lowered the after-tax cost of farm capital. Unsurprisingly, from 2005 to 2010 depreciation expenses for the average Heartland farm increased by 25 percent (table 2).

The increase in the demand for farm machinery appears to have caused machinery prices to increase. From 2005 to 2010 the nation-wide price of a large, two-wheel-drive tractor increased by 16 percent. Higher prices for new machinery makes it more expensive to replace 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 percent.

Just as the lack of change in area cultivated meant that farmers did not need to buy more tractors, it also meant that they didn't need more labor. Indeed, cash labor costs for the average Heartland farm only increased by 4 percent as did the average weekly wage for someone employed in crop production establishments in one of the key Heartland states (table 2). This suggests that the small increase in cash labor costs reflects growth in wages, not employment.

Who Gains from Higher Crop Prices? A Conceptual Framework

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, managerial ability, or farming expertise. The constant returns to scale technology f combines the inputs to produce a composite crop. We abstract away from land use changes from suburban sprawl or other sources and assume that land available to grow crops is fixed. Because of the fixity of land, nonland inputs have a declining marginal product.

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.[3]

[3] Although there was a small increase in wages for labor employed in crop production (table 2), this 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 one percent from 2005 to 2010.

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 or his labor and a return (θ) on land or farm capital assets that 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. Because land is fixed and is paid its marginal value product in the low and high crop price scenario the land rental price (r_t) increases in the same proportion as the crop price (p_c). Combining the conditions yields, $\frac{r_{t,low}}{r_{t,high}} \cdot \frac{p_{c,high}}{p_{c,low}} = \frac{f'_{t,low}}{f'_{t,high}} = 1$. The first equality comes from the assumption that land is paid its marginal value product. The second equality is because the farm uses the same amount of land in the high and low price scenarios and so the marginal product of land is the same in both scenarios.

We also assume that global market changes mean that farm capital and fertilizer prices also increase. In the short term, the stock of human farm capital will change little because it takes time to develop farming expertise. The global industry producing physical farm capital like machinery experiences higher costs as it expands. The same holds for the fertilizer industry. In contrast, the crop price has no effect on the wage because of the small role of farming in the local labor market. Use of farm capital and fertilizer increases as long as the percent increase in their prices is less than the percent 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 farmers earning higher returns to land and farm capital; from greater use of labor by the farm; and from landlords (who are not farmers themselves) earning higher returns to land. The farmer earns more income from higher rental prices (, or put differently, from earning a return of θ on wealth created by higher land and farm capital prices. He initially owns t_f acres and k_f units of farm capital, where the f subscript stands for farmer. 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. 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 that were earning θ elsewhere, which is what he will earn on new investments in land or capital.

The second primary 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 for a moment that a farmer's wage could be separated into a payment for labor and a payment for human capital, a farmer owning no land or farm capital, would still just earn a wage on his labor. More labor used, either from the farmer or a hired person, generates more labor income.

The last primary 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 primary income effects are therefore a farm proprietor income effect, a farm wage and salary effect, and a landlord income effect, defined as

(1a) $\Delta\, Farm\ proprietor\ income\ = \Delta r_t t_f + \Delta r_k k_f,$

(1b) $\Delta\, Farm\ wage\ and\ salary\ income\ = w\Delta l$

(1c) $\Delta\, Landlord\ income\ = \Delta r_t t_l$

where Δl is the change in optimal labor use.

There are several possible secondary income effects. One may stem from greater nonfarm employment and earnings. We assume that the local wage does not change in response to the higher crop price directly or through the primary income effects. Nonfarm labor income can still increase to provide services or inputs to farms or to meet the additional consumer demand caused by higher incomes. Another secondary income effect may come from higher returns on the capital holdings of local residents. An increase in eating out by local residents, for example, would increase the returns to the restaurant owner.

The Effect of Higher Crop Prices: Empirical Strategy, Identification, and Estimation

Equation (1a) shows the channels through which a higher crop price leads to higher farm proprietor income. The terms such as the increase in the rental price of land or farm capital determine how a dollar 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

(2a) $\Delta\ Farm\ proprietor\ income\ = \alpha_0 + \beta_0 \Delta Revenue + \varepsilon$

(2b) $\Delta\ Farm\ wage\ and\ salary\ income\ = \alpha_1 + \beta_1 \Delta Revenue + \varepsilon$

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 equation

(2c) $\Delta\ Property\ income = \alpha_2 + \beta_2 \Delta Revenue + \varepsilon$

reflects how a dollar in agricultural revenue translates into property income, which in addition to land rental income received by nonfarmers, also captures dividends paid by incorporated businesses and rental income from nonfarm properties. The coefficient β_2 therefore captures some of the secondary income effect described in the previous section.

Any effects on nonfarm labor earnings or nonfarm proprietor income are captured by:

(2d) $\Delta\ Nonfarm\ nonproperty\ income = \alpha_3 + \beta_3 \Delta Revenue + \varepsilon$

Because total personal income equals the sum of farm income, property income, and nonfarm nonproperty income, the sum of the βs gives the total income created by a $1 increase in agricultural revenues caused by higher crop prices.

There are two challenges to estimating (2a)-(2d). First, counties abundant in farmland have long experienced secular trends in migration and therefore 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, the equations are more appropriately written as

(3) $\Delta y = \alpha + \beta \Delta Revenue + (\rho Land + \varepsilon)$

Multiplying the change in the crop price with the average county yield and the acres of cropland in the county approximates the change in revenue from a higher crop price. 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 $\rho Land + \varepsilon$, 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.

The second challenge in estimating β concerns changes in revenues: they are imprecisely measured; they are potentially correlated with local economic conditions affecting land use; and lastly, the changes associated with livestock operations, which also experienced an increase in output prices, were offset by higher feed costs. We address all three challenges by instrumenting 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 accounts for classical measurement error, where error in measurement is uncorrelated with the error in the regression model. It also isolates the change in revenues directly linked to the change in global crop prices as opposed to an endogenous supply response. Lastly, the amount of high-quality land is correlated with crop production and therefore the change in revenues that translated into higher income.

Estimation

Instead of using annual variations in revenue, which is imprecisely measured, 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 2005-2010 as the second period and 2000-2005 as the first period. Except for a temporary increase in 2004, corn and soybean prices were generally flat for the first five years of the decade. Prices then increased in next five years, first increasing late in 2006, further spiking late in 2007 before receding to still high levels in 2009 and then spiking again in 2010 (figure 1).

Adding control variables and crop reporting district effects gives our base empirical model.

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

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 population density, the share of the population with at least a bachelor's degree and the share between the ages of 25 to 64, per capita employment in manufacturing, construction, and retail and 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 $\eta_{crd(i)}$ term accounts for geographic differences between counties in different crop reporting districts. The districts group agriculturally similar and geographically contiguous counties in the same state. In the Heartland there are roughly 10 counties per district.

To reduce the skewness of the dependent variable, we normalize it by population in 1999. We normalize the change in revenues similarly, and can thus interpret the coefficient β as the number of dollars or jobs associated with an extra dollar in revenue.

We use (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 nonproperty income to estimate β_0, β_1, β_2, and β_3. For employment, we look at total employment, which we break into farm employment and nonfarm employment. Finally, we look at changes in population.

In all cases, we instrument the change in agricultural revenues with the county's endowment of high-quality land. A first stage regression (shown in the appendix) confirms that the number of acres of high-quality land is strongly correlated with the change in revenue. Each acre was associated with a $126 dollar increase in agricultural revenues (s.e. 30). The corresponding F-statistic for the statistical significance of the instrument (16.9) demonstrates its strength. We calculate robust standard errors clustered by crop reporting district.

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.[4] There are eight Land Capability Classes based on the land's limitations for agriculture and risk of soil erosion. Land in Class I or II is well suited for intensive crop

[4] For more information on the SSURGO Database visit http://soils.usda.gov/survey/geography/ssurgo/

production, and this is what we define as high-quality land. The total acres in the two classes matches well with acres harvested: 51 percent of the land in the average county is in Class I or II; the 1997 and 2002 Censuses of Agriculture indicate that 54 percent of the average county in the Heartland was harvested.

The key independent variable, agricultural revenues, and all of the outcome variables come from the Bureau of Economic Analysis as part of its Local Area Personal Income and employment estimates. We define agricultural revenues as the Bureau's estimate of gross farm receipts sales. Receipts include farm program payments such as direct payments and crop insurance indemnities, but the largest component is cash receipts from marketing crops and livestock. The Bureau calculates 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.

Total personal income as estimated by the Bureau is a comprehensive measure of income received by a county's residents. For the farm income we use the Bureau's estimates of farm proprietor and farm wage and salary income. Farm proprietor income captures income going to sole proprietor and partnership farms. It 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.

We use the Bureau's dividend, interest, and rental income as our measure of property income earned by county residents. It 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 nonfarm landlord income. It includes all passive income such as rental income from owning nonfarm properties. To be clear, property income includes passive income received by a farmer and not reported as part of farm business income on IRS Schedule F. It also includes dividend income received by shareholders of corporate farms.

The last category of income is nonfarm nonproperty income, which is calculated by subtracting farm and property income from total personal income. Subtracting farm and property income 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's estimate of total employment, which is then separated into farm and nonfarm employment. Lastly, population is the Census Bureau's mid-year population estimate. We provide the definitions of all outcome variables in table 3.

Study Region

Our initial sample includes all the counties in the Heartland region as defined by the USDA\Economic Research Service by grouping counties characterized by similar types of farms and soil and agro-climatic conditions. Given its favorable climate and soils, cash grains like corn and soybeans dominate the agricultural landscape of the Heartland, with the region accounting for more than half of the cash grains produced in the country (Hoppe and Banker 2010). States with counties in the Heartland are Kentucky, Ohio, Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, and South Dakota. 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 counties, which are colored green in figure 2.

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 total farm income (farm proprietor income plus farm wage and salary income) accounted for 3.3 percent of total income; farm employment accounted for about 5 percent of total employment. Still, relative to the change in the prior five years, agricultural revenues in the average sample county increased by $28.3 million from 2005 to 2010. 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, who faced higher feed costs over the period. As mentioned previously, revenue increases from higher crop prices are nonetheless associated with greater endowments of high-quality land, which is how their effects are identified in our regression equations.

[Table 4]

Results

Higher crop prices led to greater personal income by increasing farm and property income. A dollar more in agricultural revenues increased personal income by 67 cents. The estimate is consistent with Brown et al. (2013) who found that a one dollar increase in farm revenues between 2002 and 2007 led to a 48 cent increase in personal income for Midwestern U.S. counties. Of the total income effect, we find that farm proprietor income accounted for 39 cents, farm wage and salary income 2 cents, and property income 24 cents. There was no statistically or economically significant effect on nonfarm nonproperty income.

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. Adding one acre of high-quality land to a contiguous county would therefore increase the average of contiguous counties by 1/6. The estimates therefore imply that adding one acre of high-quality land would increase farm proprietor income by $3.5 (=21/6) and property income by $4.1 (=25/6). Given that each acre of high-quality land was associated with a $126 increase in agricultural revenue, the estimates imply that a dollar increase in agricultural revenues in contiguous counties was associated with roughly 3 cents more in farm proprietor income and 3 cents in property income. Put differently, for each dollar in revenue in the county, six cents of income were generated for farm proprietors and property owners in contiguous counties.

The effect of revenues in contiguous counties on farm proprietor income may be because large-scale farms, which tend to be more profitable, are more common in multi-county regions 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, a resident in one county may simply be more likely to own farmland in contiguous counties if the counties have lots of farmland.

It may seem surprising that the effect on property income accounts for 36 percent (=0.24/0.67) of the total income effect. As highlighted in the theoretical section, the inelastic supply of land allows landowners to capture much of the greater income from crop prices. (If much land could come out of alternative uses, the total amount of land in crops would increase but the additional returns earned by landlords would be small – the mere difference between the return in the alternative use and the return in agricultural use). Moreover, much land is owned by landlords who live near the land that they own but are not farmers. Taking the land that farmers rented from such landlords and assuming that all of it is cropland implies that in 1997 landlords owned 60 percent of the cropland in sample counties.[5] Furthermore, most landlords live near the land they own: nationally, nearly 60 percent of landlords live within five minutes of the farm that rents their land (Nickerson, et al., 2012). The percentage living in the county where their land is located would be even higher.

Through back-of-the-envelope calculations, we estimate that increases in farmland rental rates account for two-thirds of the increase in property income. Relative to the prior five year period, real cash rents Iowa increased by $34.50 per acre from 2005 to 2010. Each acre of quality land increased agricultural revenues by $126 and property income by $30.24 (=$126 x 0.25). Assuming that 60 percent of cropland is owned by people who are not farmers, we estimate that $20.70 (=$34.50 x 0.60) or about two thirds went to nonfarmers.

The other third of the increase may reflect greater dividend payments by corporate farms. According to the 2010 Agricultural Resource Management Survey, corporate farms accounted for 12 percent 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 would be 44 cents per dollar in revenue (= 0.39/ (1-0.12)). It is therefore plausible that corporate farm income accounts for roughly 5 cents of the 24 cents in property income.

Employment and Population

[5] From the 1997 Census of Agriculture we calculate the total land rented from landlords who are not farmers as the total land in farms (acres owned + acres rented from others – acres 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 as a zero net effect on the total in farms.

We estimate that each $1 million in additional agricultural revenues increased total employment by 2.9 jobs, of which 1.4 were farm jobs (self-employed and hired). The estimates suggest a farm-nonfarm employment multiplier of around 2, but the total employment effect is statistically insignificant and the estimated effect on nonfarm nonproperty income suggests no increase in nonfarm full-time equivalent jobs. (BEA employment data combine full and part-time jobs.) Moreover, we find no evidence of an effect on population, implying that any employment opportunities created were insufficient to cause people to move to the county or keep from outside the county.

Does double-differencing matter?

Accounting for prior trends through double differencing clearly matters for estimates. Using a first-differenced model (2005-2010) with control variables at their 2004 values gives smaller estimates of the income and employment effects compared to the double-differenced model, which is expected if agricultural counties were experiencing a prior trend of economic decline. The point estimate for the effect of an extra dollar of revenue on nonfarm nonproperty income is -0.13. For property income, the effect is positive but much smaller than the double-differenced estimate (0.06 compared with 0.24). Differencing mattered the least for farm income, which only declined from 0.39 to 0.28.

The employment and population effects in the first-differenced model are also substantially smaller, implying that counties abundant in quality land were experiencing 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 almost three nonfarm jobs, and a population loss of close to seven people.

Discussion

From 2005 to 2010 agricultural revenues in the average sample county increased by $54 million. The estimated marginal effects imply that the increase created $36 million in income to residents, a 3.8 percent increase over the 2005 level. In terms of elasticities, a one percentage point increase in agricultural revenues led to a percentage point increase of 0.09, 1.87, 0.63, and 0.21 for total income, farm proprietor income, farm wage and salary income, and property income.

A 3.8 percent 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.

Assuming that only farm jobs were created by the increase in crop prices and agricultural revenues, higher crop prices increased employment in the average county by 0.5 percent (≈77/16,968). Incorporating the (statistically insignificant) point estimate for the effect on nonfarm jobs implies an employment increase of one percent.

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-20th century in and around the Ogallala aquifer, which covers much of the U.S. Great Plains. They 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.

If yield shocks from a changing climate affect rural residents, our findings suggest that the primarily channel is unlikely to be through agricultural revenues. In their county-level study of the Corn Belt Region, Feng, Oppenheimer, and Schlenker (2012) look at the relationship between weather shocks to crop yields and migration in the 1970-2009 period and find a substantial response of migration to yields. They explain their findings by suggesting a considerable spillover effect from agriculture to other sectors of the economy. Our findings suggest otherwise.

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 employment multipliers because labor supply is more elastic locally than nationally. Using local revenues to estimate multipliers, however, only captures the nonfarm jobs and income located near where production occurs. This estimated multiplier may still capture to some extent the effect from 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 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. On the other hand, some agricultural-related employment effects are concentrated in a few places and are not spatially correlated with production (e.g. the home county of Cargill and John Deere). County-level regressions using agricultural revenues as the key independent variable will not capture jobs created at John Deere or the spillover effects in other rural counties.

Conclusion

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 that allow farmers (and other businesses) to expense more of their capital purchases in the year acquired, increasing the tax savings from such 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.

Our finding that property owners who are not farmers capture more than a third of the local income from higher revenues could be interpreted as indirect evidence that explains the recent dramatic increase in farmland values. But, income captured by landowners is not a measure of how attractive farmland is as an investment. This requires estimating the longer-run returns to farmland and comparing them with the returns to similar assets.

Still, the evidence that much of the gains from higher prices accrue to landowners underscores the relationship between local income and local ownership of farmland. With most U.S. farmers near retirement age, much farmland will change hands in the next decade. Anecdotally, it appears common for a farm household to transfer land to its children, most of whom have left the area. If they maintain ownership the income from higher crop prices will increasingly leave the county where the farm is located, weakening the link between agricultural revenues and local income.

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Tables

Table 1. Per Acre Margins Increased Dramatically for Corn and Soybeans in the 2000s

Year	Corn	Soybeans
2000	103	133
2005	83	195
2010	362	317
Change, 00-05	-21	62
Change, 05-10	279	123

Note: Per acre margins are the value of production less operating costs. They are based on USDA-ERS Commodity Cost and Returns reports (USDA-ERS, 2012a), accessed at http://www.ers.usda.gov/data-products/commodity-costs-and-returns.aspx. Monetary amounts are converted to 2010 dollars using the Consumer Price Index-U series.

Table 2. Higher Prices and Costs for Land and Farm Capital

Input	2005	2010	Percent 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: 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. Monetary amounts are in 2010 dollars.

Table 3. Definitions of Key Variables

Variable	Description
Agricultural revenues	Farm gross receipts, including federal farm program payments
Income	
Total personal income	Income from all sources received by residents of the county
Farm proprietor income	Income earned by farm proprietorships and partnerships
Farm wage and salary income	Wages and salaries paid to farm labor, 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

Notes: 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

Table 4. Sample Descriptive Statistics

	Mean	S.D.	Median
Doubled Differenced Variables (2010-2005)-(2005-2000)			
Agricultural Revenue	28,368	33,751	26,893
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

Notes: 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 age 25-64 are based on the 2000 Census. Monetary amounts are in 2010 dollars.

Table 5. Agricultural Revenues and Income

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	0.67***	0.39***	0.02***	0.24**	0.02
	(0.14)	(0.09)	(0.01)	(0.10)	(0.15)
High-quality land in contiguous counties	41.76	20.99*	-0.11	24.81*	-3.93
	(31.78)	(10.80)	(1.45)	(12.92)	(28.12)
Population density (1,000s)	-0.88	2.39**	0.10	-0.91	-2.47
	(4.96)	(1.15)	(0.09)	(1.13)	(5.00)
Share bachelor's degree or more	7.97	1.17	0.10	-3.44	10.14*
	(5.31)	(1.69)	(0.21)	(2.24)	(5.46)
Pop. ages 25-64	0.74	3.90**	-0.04	-6.52**	3.40
	(8.06)	(1.86)	(0.19)	(2.64)	(6.70)
Share emp. in manufacturing	-0.41	-1.50*	0.07	-1.49*	2.52
	(3.06)	(0.91)	(0.05)	(0.88)	(3.27)
Share emp. in construction	15.23**	7.79**	-0.25	2.36	5.33
	(6.64)	(3.77)	(0.54)	(4.02)	(5.68)
Share emp. in retail	-12.04*	3.00	-0.36	2.15	-16.83***
	(6.79)	(2.52)	(0.38)	(3.60)	(6.13)
Crop reporting district dummies	yes	yes	yes	yes	yes
Rural-urban continuum code dummies	yes	yes	yes	yes	yes
Observations	427	427	427	427	427

*** p<0.01, ** p<0.05, * p<0.1

Notes: Robust standard errors clustered at the crop reporting district are in parenthesis.

Table 6. Agricultural Revenues, Employment, and Population

	Total employment	Farm employment	Nonfarm employment	Population
Covariates	Coef/se	Coef/se	Coef/se	Coef/se
Agricultural revenues	2.92	1.44***	1.49	-0.60
	(2.14)	(0.54)	(2.04)	(1.09)
High-quality land in contiguous counties	-0.58	-0.07	-0.52	-0.15
	(0.50)	(0.06)	(0.50)	(0.30)
Population density (1,000s)	-0.01	-0.02***	0.01	0.03
	(0.10)	(0.01)	(0.10)	(0.04)
Share bachelor's degree or more	-0.13	-0.01	-0.12	0.05
	(0.09)	(0.01)	(0.09)	(0.05)
Pop. ages 25-64	-0.06	-0.01	-0.05	-0.13**
	(0.09)	(0.01)	(0.09)	(0.06)
Share emp. in manufacturing	0.09	-0.00	0.09	0.03
	(0.10)	(0.01)	(0.10)	(0.02)
Share emp. in construction	-0.18	0.03	-0.21	-0.06
	(0.13)	(0.03)	(0.13)	(0.06)
Share emp. in retail	-0.21**	-0.04**	-0.17*	-0.00
	(0.11)	(0.02)	(0.10)	(0.07)
Crop reporting district dummies	yes	yes	yes	yes
Rural-urban continuum code dummies	yes	yes	yes	yes
Observations	427	427	427	427

*** p<0.01, ** p<0.05, * p<0.1
Notes: Robust standard errors clustered at the crop reporting district are in parenthesis.

Table 7. 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
0.22*	0.28***	0.01**	0.06***	-0.13
(0.12)	(0.06)	(0.00)	(0.02)	(0.09)
Total employment	Farm employment	Nonfarm employment	Population	
-2.83***	0.01	-2.84***	-6.87***	
(1.09)	(0.16)	(1.04)	(1.46)	

*** p<0.01, ** p<0.05, * p<0.1

Notes: 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 are defined as the change from 2005 to 2010. Also, the 2004 values are used for control variables not from the 2000 Census.

Table 8. Aggregate Income Effects and Elasticities for the Average County

Outcome	Estimated Aggregate Effect 2005-2010, ($1,000s)	Mean Value, 2005 (1,000s)	Percent Increase (over 2005 levels)
Total personal income	35,829	936,736	3.8%
Farm proprietor income	20,951	26,495	79.1%
Farm labor income	1,185	4,480	26.4%
Rent income	12,751	140,505	9.1%
Farm employment (jobs)	77	843	9.2%
Income elasticities with respect to agricultural revenues			
Total personal income		3.8/42.2=0.09	
Farm proprietor income		79.1/42.2=1.87	
Farm labor income		26.4/42.2=0.63	
Property income		9.1/42.2=0.21	
Farm employment		9.2/42.2=0.22	

Figures

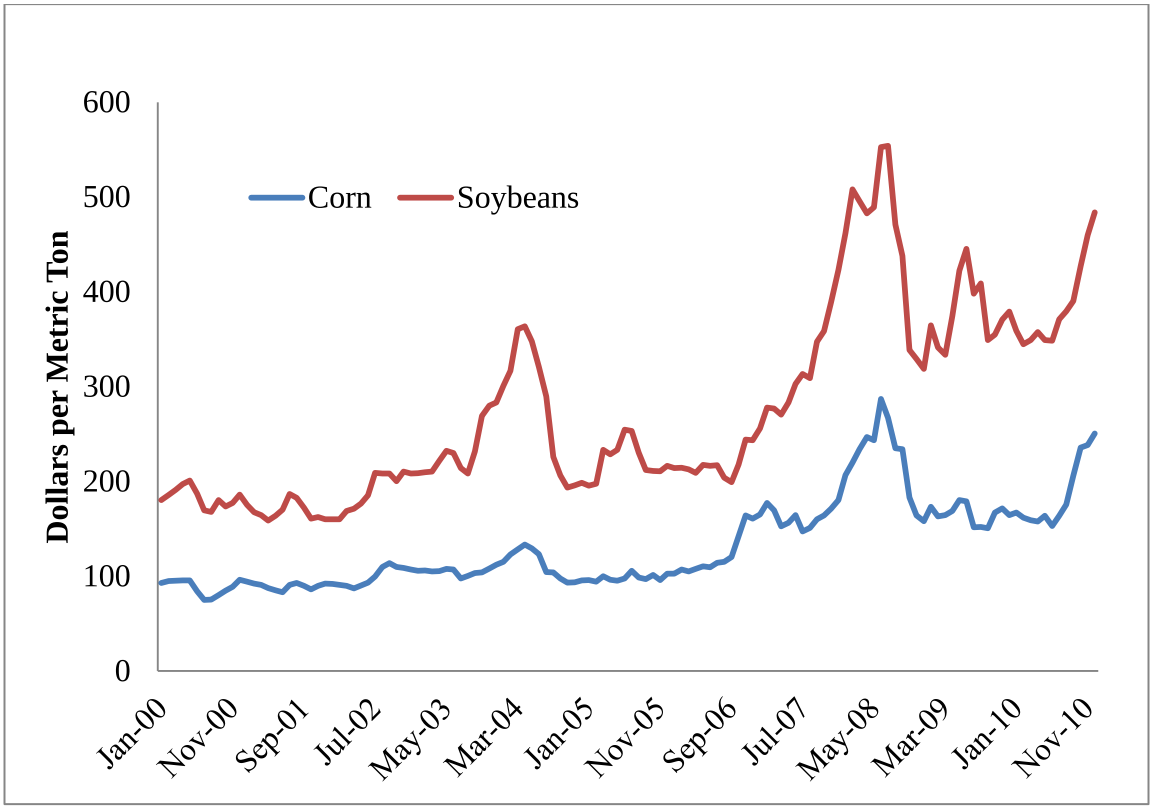

Figure 1. The Increase in Corn and Soybean Prices, 2000-2010

Source: World Bank. Accessed at www.indexmundi.com

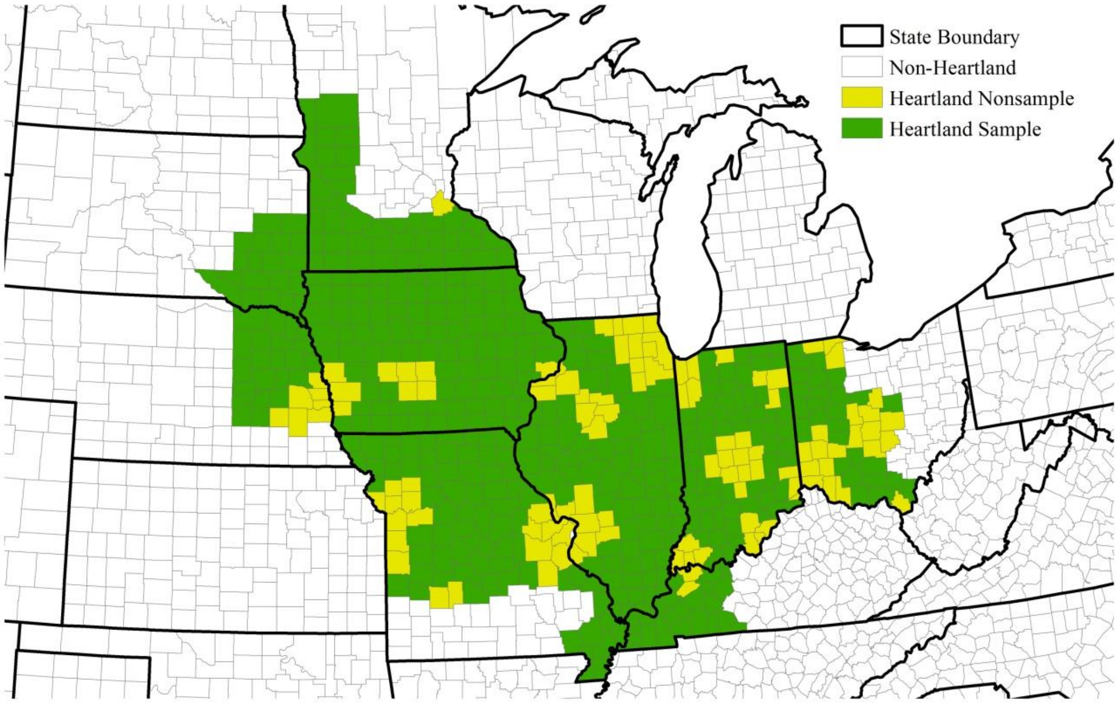

Figure 2. Heartland Counties Used in the Empirics

Appendix

Table A1. Land Endowments and Changes in Agricultural Revenues

Covariates	Coef/se
High-quality land	126.20***
	(30.69)
High-quality land in contiguous counties	13.83
	(22.51)
Population density	-5.03**
	(2.38)
Share bachelor's degree or more	1.80
	(3.27)
Pop. ages 25-64	1.64
	(4.79)
Share emp. in manufacturing	-0.08
	(2.03)
Share emp. in construction	14.38**
	(6.14)
Share emp. in retail	1.17
	(3.33)
Intercept	-1.08
	(2.89)
Crop reporting district dummies	yes
Rural-urban continuum code dummies	yes
Observations	427
Adjusted R2	0.49

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors clustered at the crop reporting district are in parenthesis.