Local Effects of Hog Production on Farm and Non-Farm Economic Outcomes

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Selected Paper prepared for presentation at the Agricultural & Applied Economics Association 2010 AAEA,CAES, & WAEA Joint Annual Meeting, Denver, Colorado, July 25-27, 2010

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PRELIMINARY DRAFT -- PLEASE DO NOT CITE OR CIRCULATE WITHOUT PERMISSION

Abstract
In the past 20 years the average scale of hog operations has expanded more than fourfold, and some of the new large-scale hog feeding operations have been opposed by residents in some communities. While the environmental effects of such production have been relatively well studied, less examined are its potential positive effects on local labor markets and economies. Existing estimates based on production-function and input-output analysis imply that each additional 1000 hogs in inventory in a county generates between 3 and 7 local jobs. In this paper we adopt an econometric approach instead, to estimate the effects of changes in hog production on changes in both farm and non-farm outcomes. We find that total county employment increases by less than previously reported, with about two additional jobs being created per 1000 head of hogs in inventory.

JEL Codes: Q5

Keywords: Employment, Income, Hogs

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Introduction

Sustained increases in labor productivity are widely recognized to be the main historical cause of rising standards of living. In the short run, however, the transition from smaller-scale and more labor-intensive production to larger-scale more capital-intensive methods can create significant economic and social dislocation, and such transitions often lead to calls for policy intervention. In the retail trade sector, for example, worries about the effects of Wal-mart super-stores on local employment and wages, and on the survival of smaller retail operations, has led to vigorous local opposition in many instances, and a growing body of empirical research on Wal-mart's labor market impact (Neumark *et al* 2005, Basker 2005, Artz and Stone 2006, Basker 2007). Consolidation in the meat-packing industry, and the arrival in rural areas of large meat-packing plants staffed primarily by immigrant labor, have also generated concern and research attention (Artz et al 2007, Artz et al 2008). Here the perceived negative externalities relate not to job-destruction but to tensions associated with demographic change, and the perception that foreign-born workers and their children are a burden on local educational and social resources.

Similarly, large scale livestock operations represent a leap forward in agricultural productivity, but have provoked opposition at the local level. In addition to aesthetic concerns, opponents cite a growing body of research that finds negative effects of such operations on health and the environment (Thu et al 1997, Donham 2000, Wing and Wolf 2000, Sneeringer 2009a, 20009b, 2010). In deciding whether to accept these costs, state and local officials would benefit from accurate estimates of the corresponding economic benefits of a large-scale animal feeding operation being located in their community. In this paper we address this question using empirical methods similar to those used in the studies of the retail and meatpacking sectors, cited above. We seek first to understand the relationship between hog inventories, held in farms of differing scales, and direct farm outcomes (cash receipts, net income, and the level and composition of expenditures, including expenditures on hired labor). Second, we seek to estimate the within-county indirect employment effects (at upstream suppliers or downstream processors) as well as the induced income that is generated when the direct and indirect incomes are re-spent. Our results (which are preliminary at this stage, as not all sources of data have yet been exploited, and not all econometric issues resolved) suggest that local, county-level multiplier effects are modest: we find a ratio of 0.9 between nonfarm and farm personal income attributable to hog production, which is much less than the county-level figure of 3.2 reported by Otto and Kliebenstein (1999)[2]; lower than the employment-based estimates reported by Lazarus *et al* (2002); and lower than all-livestock estimates for York county Minnesota in Lemke (2006). We also find that about two total jobs are created per 1000 hogs in inventory, compared to county estimates of between 3 and 7 in Otto and Kliebenstein. We conclude that the off-farm multiplier effects of hog-production, at the county level, may be smaller than previously reported, but we stress that this conclusion is tentative at this time.

Structural Change in Hog Production and Prior Research on its Local Economic Benefits

In the past 20 years, the size of the average hog farm has expanded by a factor of four. The 1987 Census of Agriculture counted 240,000 hog farms with inventories totaling 52 million head, for an average of 215 hogs per farm (U.S. Department of Commerce 1992). By 2007, the numbers were 75,000 farms with 68 million head, or 899 hogs per farm (U.S. Department of Agriculture 2009). The most rapid growth has occurred among farms with inventories of 2000 or more, whose share of the U.S. total rose from 30 percent in 1992 to 80 percent in 2004 (Key and McBride 2007). Coinciding with this growth in the scale of operations is an increased use of production contracts, which allow for a higher degree of specialization. Operations that specialize in feeding hogs that have already been weaned and partially

[2] Otto and Kliebenstein have posted county-level analyses on their website. In each county we examined, the ratio of estimated personal income in all nonagricultural activities to estimated income from farming, all driven by hog-production, was 3.2 to 1.

raised (called feeder-to-finish operations) made up 22 percent of all hog enterprises in 1992, rising to 77 percent of enterprises in 2004.

These increases in scale, as well as technological changes, have caused production costs (measured in dollars per hundred pounds of weight gain) to fall by 28 percent between 1992 and 2004 for traditional farrow-to-finish operations, and by 44 percent for the more specialized feeder-to-finish operations. Over the same period, labor usage rates fell by 53 percent for farrow-to-finish operations and an astonishing 83 percent for feeder-to-finish operations. Meanwhile, the real cost of the amount of feed required to add 100 pounds to a hog has also fallen, by 15 percent and 44 percent for the two types of operations (Key and McBride 2007).

As labor and input requirements fall steadily over time, hog farming generates less demand for local labor and less demand for purchased feed and other inputs per unit of output. Moreover, there is some evidence that larger operations purchase a smaller share of their inputs in local markets, which would reduce the local (but not the cumulative national) economic spill-over effects of hog farming. Lazarus *et al* (2002) report survey data from four Minnesota counties that suggests that larger operations buy about half of their inputs in the same county, compared to about 2/3rds for smaller operations. It may also be the case that contractors (who provide feed, technical assistance, and supplies) are less likely to make these purchases in the same county as the contractee's farm, compared to the purchasing patterns of traditional farrow-to-finish producers, although we are not aware of survey data on this question. Similarly, the profits accruing to contractors are unlikely to be re-spent in the local county if the contractors are not local, whereas much of a traditional proprietor's income will be re-spent locally. For all of these reasons we would expect the full local employment impact of hog farming to be falling over time, on a per hog basis.[3]

[3] In this paper we do not examine the relationship between production costs and the price of pork, or the effect this has on consumer welfare.

Existing estimates of the direct, indirect and induced employment effects of hog farming rely on input-output analysis, frequently using the Minnesota IMPLAN (1999) software. We take a minute to review the strengths and weaknesses of this approach before presenting our empirical alternative to it. The starting point for a credible input-output analysis of hog farming is an estimate of the production functions and input mixes that are specific to different types and scales of operation. Otto and Kliebenstein (1999) calculate that the Iowa pork industry employs 18,000 people in hog production and another 9,000 in related agriculture. Nonfarm indirect and induced employment amounts to an additional 60,000 people in the state, for a total of 87,000. In their county-level analyses they conclude that each hog-farming job in a county produces about half of one additional job in other farm activities, and 3.0 additional jobs in other sectors in that county. In income terms, the ratio of all nonfarm to farm-generated incomes in the county due to hog production is estimated at 3.2 : 1.

This analysis, however, is marred by the assumption that non-hog-farm employment (indirect and induced) will be distributed across counties in proportion to their share in the state's total hog inventories, which is clearly not the case. For example, employment in meat-packing may be located in counties other than those where the hogs are raised. If Lazarus *et al* are correct that one-third to one-half of inputs are purchased out-of-county, but that about 80 to 90 percent of inputs are purchased in the same state, then allocating the state numbers across counties in this fashion will impart an upward bias to the estimated local employment multipliers for the hog-farm counties.

Lazarus *et al*'s analysis for Minnesota includes a survey of producers, which is used to determine the mix of inputs to production, and the share of each input that was purchased in the same county, and in the same state. Their results are reported in terms of employment (as opposed to personal income), and are broken out by type of operation. Their analysis is designed to compare the full employment impacts of different types of hog operations, from traditional small farrow-to-finish farms all the way to fully specialized separate large operations for farrowing and for finishing. Not surprisingly, they find that the direct employment associated with the large-scale most specialized techniques is about 78 percent less than under the traditional arrangement. However, total county-level employment, including indirect and induced jobs, is just 20 to 30 percent below the small-farm baseline, depending on the county. Thus, a greater share of the full employment impact occurs through indirect and induced channels when farms become larger and more specialized, but the total impact is still reduced. The estimated ratio of nonfarm (indirect and induced) to direct farm jobs varies from about 1.0 (for traditional small scale operations) to a high of about 5.5 for the most specialized format.

Estimates such of these have been influential in local- and state-level decisions to provide incentives to attract the pork industry, and the type of pork production invited by welcoming deals is, in most documented cases, of the large-scale, specialized variety. For example, in 1991 Oklahoma relaxed its anti-corporate farming laws and adopted a number of tax breaks and special agreements, precipitating an 800% increase in the number of hogs in the Panhandle by 1997 (North Central Regional Center for Rural Development, 1999). Similarly, between 1992 and 2002, North Carolina rose from being the sixth-largest hog producing state to the second, growth that was widely argued to have been brought about by a welcoming regulatory and tax environment (Stith and Warrick, 1995; Sneeringer, 2009b). Given their relevance to policy decisions, it is important to be confident in the validity of the employment estimates, and the indirect and induced employment multipliers.

While attractive in principle, the input-output modeling approach is heavily dependent on the choice of parameters that define per-unit input requirements and propensities to purchase each input locally. All of these parameters may differ by year, size and type of operation, and, as Lazarus *et al* note, they may also differ by county, since some counties can supply a wider range of the needed goods and services than others. The results also depend strongly on the ability of the social accounting matrix that underlies the input-output model correctly to describe the inter-relations among the industries that are involved in hog farming, and in this endeavor precision is limited by the need to aggregate disparate products and labor categories to conform to the available data. Results for induced employment, in turn, depend strongly on estimates of the consumption propensities of each class of income recipient across all goods in the model, and of the local share of each component of this consumption, the compilation of which represents no small feat. Finally, results will depend on the assumptions made about the overall number of hogs sold by farms in the county (which will vary both with national trends and as the county's market share varies), about prices of inputs and outputs, and about the evolution of the mix of large and small hog operations in the county. A number of sociological and small-scale studies have examined the experiences of rural communities after the arrival of large-scale hog production (North Central Regional Center for Rural Development, 1999; Thu and Durrenberger, 1998). These studies point out that large-scale and/or contract production may drive out smaller farmers, yielding little local economic benefit at the aggregate level. This can occur because of the lower costs of larger operations, but also through anti-competitive mechanisms, such as when the contractor owns the nearest processing facility (slaughterhouse) and only accepts contracted hogs. How these processes unfold is an empirical matter, and not one that is amenable to analysis via input-output modeling.

We take an alternative approach, which to the best of our knowledge is the first purely empirical attempt to address this question. Rather than building on a foundation of prior estimates of input requirements, local purchase coefficients, consumption propensities, and interindustry linkages, we use observed data on local economic outcomes to estimate the consequences of observed changes in hog inventories, and of the growing scale of operations, controlling econometrically for as many confounding factors as we can. Our methods are detailed below, following a description of our data.

Data

Our primary explanatory variable is the annual (December 1st) county-level count of hog inventories from the National Agricultural Statistics Service (NASS). However, NASS does not provide measures for all states in all years, and stops reporting county-level measures for certain major hog-producing states in more recent years. Using all available data in an unbalanced panel could lead to incorrect conclusions, since sample inclusion may be related to outcomes of interest. In creating our balanced panel of states, and in anticipation of our planned incorporation of data from the U.S. Census of Agriculture [pending] we restrict ourselves to years in which the Census was conducted, namely, 1982, 1987, 1992, 1997, 2002, and 2007. Nineteen states have county-level observations in each of these six Census years, including Alabama, Georgia, Illinois, Kansas, Kentucky, Minnesota, Montana, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, West Virginia, and Wisconsin. Because of differential reporting between data sets for the consolidated cities in Virginia, we exclude this state.

In the NASS public-use data, certain counties are suppressed, for reasons of confidentiality. Thus, if a county has a single operation with 10,000 hogs, this value is suppressed in the NASS data. However, the maximum reportable value is variable and unknown, making it difficult to impute suppressed values by means of techniques for analyzing truncated distributions. When suppression occurs, NASS groups the county in question with other counties, and reports the total value for all of these counties as a "combined county."

To impute values for the suppressed counties, we make use of reporting at nested geographic levels. NASS divides each state into Agricultural Statistical Divisions (ASDs). Within each ASD are counties. NASS provides values for unsuppressed counties, combined counties (which include the totals of suppressed counties), and ASDs. For example, the data might look like the following:

Geographic Unit	**Hogs**
County A in ASD 10	300
County B in ASD 10	4,000
County C in ASD 10	6,000
Combined Counties in ASD 10	1,200
ASD 10	11,500

Here, County A, B and C are contained within ASD 10 and have unsuppressed values. Given the observation for the "Combined Counties in ASD 10," we can ascertain that there are suppressed counties within ASD 10. Note that the total number of hogs in ASD 10 (11,500) is equal to the sum of hogs in Counties A, B, and C, as well as the Combined Counties.

We next obtain from NASS a list of counties within each ASD. From this we might learn that ASD 10 has five counties, A through E. Comparing this list to the data table, we see that Counties D and E must comprise the "Combined County" in ASD 10. Given that there are two counties and a total of 1,200 hogs in the Combined County, we impute a value of 600 hogs to Counties D and E. We repeat this process for all ASDs. Since different counties are grouped into the Combined County category in each ASD in each year, we do this for each year.

Data on our regional economic outcome variables come from the Regional Economic Information System (REIS), a product of the U.S. Bureau of Economic Analysis. The REIS data include annual county-level measures for a number of farm and non-farm economic variables. From all of these data sources we compile county-level data for the six Agricultural Census years between 1982 and 2007. The levels of these variables over time are shown in Table 1. We then calculate the changes in level between consecutive years, pertinent for our empirical strategy described below; summary statistics for these changes are shown in Table 2.

We obtain a measure of property values from the U.S. Census of Population and Housing from 1980, 1990, and 2000. We use publicly available measures of county-level median home price (contained on U.S. Census of Population and Housing Summary Tape File 3A) for the three Censuses and create linear extrapolations of median home prices for the Agricultural Census years before 2000 (five-year intervals between 1982 and 1997). For 2002 and 2007, we project median home values by calculating annual changes between 1990 and 2000.

Our value of population density is calculated from the REIS reported value of population divided by the land area in square miles in the county. The land area variable comes from the publicly available 2000 U.S. Census of Population and Housing Summary File 1.

Finally, we exclude all predominantly metropolitan counties, defined as those containing urban areas of 250,000 or more people in the year 2000. We use the year 2000 metro/nonmetro county definitions for all years in the study so as to have a balanced panel of counties; the alternative of using the periodically updated metro/nonmetro definition would cause the sample of usable counties to change over time.

Empirical Strategy

Our goal is to estimate the effects hog production has on local economies. We examine several types of outcome measures. First, we examine a factor that should depend strongly on hog production: cash receipts from livestock. This outcome serves more of a confirmation test to check that our hog production measure actually reflects the first stage of economic effects.

Second, we examine outcomes related to upstream industries that may be affected by changes in local hog production; these include cash receipts from crops and farm expenditures on feed and livestock. A comparison of the effects of hog inventories on feed expenditures with the effects on crop receipts provides a measure of the local content of feed purchases.

Third, we examine two measures of the earnings of farm labor: hired farm labor expenses, and farm proprietor's incomes. A third measure, total net farm income, includes incomes accruing to corporate farms (as opposed to farms run by proprietors.) Comparison of the relative importance of owner's versus hired labor's earnings can shed some light on changes in income distribution brought about by the changes in the methods of production.

Our fourth type of outcome covers off-farm economic outcomes to measure local spillover effects from hog production. These include non-farm measures of personal and proprietor income. We can then divide the observed effect on non-farm outcomes by the effect on the farm outcomes to derive a multiplier comparable to the ones discussed above.

Finally, we look at overall measures of local labor market performance which cover farm and non-farm outcomes. These include per capita personal income, total employment, average wage per job, and average proprietor's income. Unfortunately, we cannot disaggregate average wage and average proprietor income into its on- versus off-farm components.

Our regression strategy attempts to estimate the effects of hog production on these outcomes. Two primary concerns arise when attempting to estimate the effects of any industry moving to an area: bias in the estimated coefficients of interest can arise because of omitted variables and/or endogeneity. We will consider both of these in turn, beginning with the more easily-overcome matter of potential omitted variable bias. Suppose a farm chooses to locate or expand in an area based on its low population density, and population density also plays a part in per capita income (e.g., if urban salaries are higher to compensate for higher housing costs). If one then estimates the association between the farm's presence and per capita income without accounting for population density, the resulting coefficients will partially reflect the association between population density and per capita income, rather than just the association between the farm's presence and per capita income.

The most straightforward method of confronting potential omitted variables bias is to assess what factors contribute to a farm's presence in the area and then control for these factors in the regression specification. Where hog production is concerned, the prior literature emphasizes that state-level regulations, population density, environmental factors such as temperature and land quality, land availability and land prices, geographic proximity to markets, historical experience with chicken production contracts, and discretionary local or state-level tax breaks and incentives are the most important factors entering into locational decisions (Sneeringer, 2009b and 2010; Abdalla, Lanyon, and Hallberg, 1995; MacDonald et al, 1999; Steelman, Page and Burton 2004; Stirm and St. Pierre 2003). Notably, labor market features are rarely cited. Feed (a primary upstream industry) and processing facilities (a primary downstream industry) are now often regarded as serving national markets; thus close proximity to these local features is regarded as unnecessary for production facility location (see, for example, Artz, Orazem, and Otto, 2007).

Our primary empirical strategy seeks to account for these various determinants by including two highly relevant time-varying factors in our equation (population density and land prices), and by using county-year fixed effects to absorb the effects of the pertinent time-invariant (or at least, very slowly changing) county attributes such as weather, land quality, proximity to markets, and historical experience with contract farming. Using county-year observations for 1982, 1987, 1992, 1997, 2002, and 2007, we calculate changes in our outcome variables between consecutive Census years. We then regress the change in the pertinent economic outcome variable on the change in hog production, which removes the effect of the county-level fixed factors described above. The estimating equation may be written:

(1) $$\Delta Y_{cst} = \alpha + \lambda(\Delta H_{cst}) + \boldsymbol{X}'_{\boldsymbol{cst}}\boldsymbol{\beta} + (\boldsymbol{State_s} \times \boldsymbol{Year_t})'\boldsymbol{\theta} + e_{cst}$$

Here, ΔY_{cst} and ΔH_{cst} refer to the changes in an outcome (Y) and the number of hogs in the county (H) between t and $t+1$ in county c and state s, respectively. $\boldsymbol{X_{cst}}$ contains population density and a measure of land value, which are the relevant county- and time-varying covariates, and are defined in time t. $\boldsymbol{State_s}$ is a vector of state indicator variables, and $\boldsymbol{Year_t}$ is a vector of year indicator variables. Interacting these two creates state-year fixed effects which control for anything that varies over time at the state level, including, importantly, time-varying state-level regulations, and general economic trends. This means that we are using only within-state time-variation to estimate effects of changes in hog production on changes in our various economic outcomes of interest.

While this specification can address many sources of potential omitted variable bias, we still face our second major concern of endogeneity. Suppose a farm chooses to locate or expand in a low per capita income area in order to be able to offer lower wages and hence reduce costs. If such a decision occurs systematically, then associations between farm presence and per capita income will partially reflect the effect of per capita income on farm presence, rather than isolating that which we desire to estimate, namely, the farm's effect on local per capita income. This reverse causality is difficult to address, but the extent to which it is a plausible source of bias depends on specific outcome under study. For example, we might expect hog production to be attracted to areas with growing agricultural receipts, which might bias our estimates of the relationship between the two. However we are less inclined to believe that hog farming is attracted to areas with high or low non-farm proprietors' income; moreover, the low labor content of hog-farming is consistent with the fact that local wage and unemployment levels are not stated to be decisive locational factors, as already noted.

In addition to contemporaneous feedbacks of the kinds just discussed, there may be feedback from financial outcomes in one period to hog inventories five years later, because positive financial outcomes can serve as sources of finance for future expansion. If so, then ordinary least squares estimation of equation (1) will not yield consistent estimates. However, Wooldridge (2002) notes that consistent estimates can be achieved using instrumental variables, namely, variables that strongly predict ΔH_{cst}, and only affect the outcome ΔY_{cst} via their effects on hog inventories. If we assume sequential exogeneity (i.e. that feedbacks from Y_{cst} to *future* levels of H_{cst} are possible, but no feedbacks from Y_{cst} to *present or past* levels of H_{cst} exist) then lagged values of ΔH_{cst} will serve as valid instruments. Thus we can in principle solve the feedback problem by using $\Delta H_{cst-1} \equiv H_{cst} - H_{cst-1}$ as an instrument for ΔH_{cst}. Results of estimating equation (1) with and without instrumenting are discussed next.

Results

Table 3 shows the results of estimating Equation (1) for 14 outcome variables, each covering 4 samples (one for the full dataset, one with extreme values removed, and two for the earlier and later time periods). The regression coefficient and standard error for the change in hogs is shown, with hogs measured in units and dollars measured in 1000s. Thus, for example, in the first row of column (i), a one hog increase in inventory in a county is correlated with a $289 increase in cash receipts from livestock and livestock products, and this result is statistically significant at the 1% level.

Column (i) in Table 3 shows the results using the full sample. Changes in hog production are positively and strongly correlated with changes in cash receipts from livestock and livestock products, as one would expect, with each extra hog generating an estimated $289 in cash receipts. Using a carcass price of $80/hog, which was the approximate average for the period, and given that between 2 and 3 hogs are produced each year per head in inventory (Key and McBride 2007), this yields a per-hog increase in cash receipts of approximately $160-$240. The upper end of this range is fairly close to our result. The results for major upstream outcomes show that cash receipts for crops increase by $30 for every extra hog. Comparing this number to the $91 increase in feed purchased suggests that about 2/3rds of purchased feed may be coming from farms outside the county.[4] Dollars spent on livestock purchases increase by $72 for each extra hog in inventory.

The on-farm labor and income measures also show strong positive partial correlations with hog production. For each additional hog in inventory, hired farm labor expenses increase by $11, net farm income creases by $108, and farm proprietors' net income increases by $71. These coefficients could be

[4] This number is higher than reported by Lazarus (2002) for Minnesota, but note that our data reflect the location of the *production* of the feed, whereas Lazarus' survey asked about the location of its purchase, i.e. the location of the distributor.

biased if positive income shocks serve as a source of finance for hogs in the next period. However, given that the next period is five year's hence, the scope for this endogeneity bias is reduced.[5]

Nonfarm personal income and total employment also appear to be significantly affected by hog inventories. Using the full sample, a single hog increase is correlated with a $109 increase in non-farm personal income. An additional 1,000 hogs is correlated with roughly two additional jobs, compared to Otto and Kliebenstein's estimates of between 3 and 7 additional jobs at the county level. Nonfarm proprietors' income shows no statistically significant relationship with hogs.

In columns (ii) through (iv) of Table 3, we estimate the main specification using different samples. In column (ii), we drop the counties which have the highest and lowest 1% of changes in each year to understand the influence of extreme values on our outcomes.[6] For many variables, estimated effects are larger than those for the overall sample; this suggests that counties experiencing rapid loss or growth of hog production are not driving the full sample results. However, there are noticeable differences for nonfarm personal income and total employment; these lose statistical significance, suggesting that only the largest changes in hog production drive changes in these outcomes. Further investigation is required to understand and properly account for the role of these extreme values.

Columns (iii) and (iv) in Table 3 show the results from dividing the sample into earlier and a later time periods, to see whether effects change over time. To make these samples of equal size, we do not use the middle time change (1992-1997) in either sample. For the farm-related variables, it appears that effects are becoming larger over time. With regards to off-farm measures, strong positive correlations

[5] Feedback of this kind would create a negative bias in the parameter on changes in hog inventories. To see this, imagine a positive income shock in time t (a large value of e_{cst}). If this feeds back positively to H_{cst+1}, then ΔH_{cst} will be increased, whereas Y_{cst+1} will not be abnormally large assuming e_{cst+1} has mean zero. The ratio of ΔY_{cst} to ΔH_{cst} is thus reduced.

[6] This removes approximately 100 observations from the sample.

are not evident. In the early period, hog production is even negatively correlated with non-farm proprietor income.

Table 4 provides results after instrumenting for changes in hogs between t and $t+1$ with the changes in hogs between times $t-1$ and t, including and excluding the extreme observations. Results without removing the big changers are shown in columns (i) and (ii). For the measures of hog production and upstream industry outcomes, the results are very similar or somewhat larger. This suggests that endogeneity does not greatly influence the original results for the full sample, and this suggestion is supported by the endogeneity test p-value being greater than 0.05 in most instances (in column (iii)).[7] The on-farm labor and income equations, however, do show signs of endogeneity. The IV specification for the full sample (column (ii)) suggests that hog production affects farm proprietor and net farm income, but has no statistically significant relationship with hired farm labor expenses.

The IV results also suggest that hog production has no statistically significant relationship with the non-farm measures. However, the p-values on the endogeneity tests suggest that the instrumental variables estimates are not statistically different from those in column (i). Hence there is no reason to prefer the IV results over the OLS results for the nonfarm measures. [More work is needed to produce more robust estimates using IV methods.]

Results excluding the largest and changes in hogs (columns (iv) and (v) in Table 4) are quite different from columns (i) and (ii). For three outcomes (cash receipts from crops, feed purchases, and hired farm labor expenses) the endogeneity test suggests there may be scope for IV estimation. More work is needed to increase the precision of these estimates and our confidence in them.

[7] The null hypothesis of this test is that the coefficient estimated by OLS is equal to the coefficient estimated via IV. When the p-value is greater than 0.05, we fail to reject this hypothesis and thus have no evidence for endogeneity of hog counts in the OLS equation. This test, however, is only valid if the instruments themselves are valid (i.e. if sequential exogeneity holds).

Discussion and Conclusion

Our results suggest that the number of local jobs created by hog production is lower than previously estimated. We find a net increase in total county employment of two jobs per 1000 head in inventory, compared to some county-level estimates as high as 7. The difference lies not in our estimates of the direct employment impact of hog-farming, but rather in our smaller estimates of the off-farm spillover effects. Given the many parameters and modeling decisions that are required for input-output analysis, it should not be surprising they do not closely agree with ex-post econometric estimates.

Our results are most robust for the on-farm outcomes; in some of our alternative specifications (in particular when extreme values are removed) we see no statistically significant off-farm effects. We also find that the on-farm effects are strongest in the more recent period.

As indicated in the text, this work is preliminary. One planned improvement is to incorporate restricted-access farm-level Agricultural Census data on hog inventories, removals, and production expenses. This will allow us to develop counts of hog inventories in, and removals from, larger versus smaller-scale farms, and it will allow us to use all 48 states with no suppression of counties.

Further work is also needed to hone our econometric specifications to better deal with possible biases due to omitted variables and the potential endogeneity of hog inventory changes, as well as the problem of high-leverage extreme values. We also plan to modify our approach to allow for non-linear relationships between our outcomes and the level of hog production, and for asymmetric reponses for counties experiencing growth in hogs versus those in decline.

Table 1: Means and Standard Deviations of Levels of Variables Over Time							
	Time period						
	Overall	**1982**	**1987**	**1992**	**1997**	**2002**	**2007**
Hogs (number of head)	17,911	14,211	14,679	16,072	19,837	20,124	22,543
	(73,550)	(25,769)	(29,838)	(46,341)	(89,424)	(95,620)	(107,609)
Population density (people per square mile of land)	53.3	51.7	50.0	52.9	53.7	55.1	56.5
	(66.86)	(63.12)	(62.39)	(65.04)	(67.41)	(69.54)	(72.77)
Median home value ($)	57,475	34,262	38,351	46,978	59,203	73,314	92,741
	(29,381)	(9,247)	(10,343)	(13,753)	(18,945)	(25,801)	(35,528)
Measures of hog production outcomes							
Cash receipts from livestock and products ($000)	24,692	11,339	15,173	21,011	26,296	28,125	46,192
	(49,034)	(16,298)	(22,727)	(34,412)	(47,081)	(50,617)	(83,242)
Major upstream industry measures							
Cash receipts from crops ($000)	17,905	8,215	9,741	14,151	20,897	18,633	35,608
	(27,172)	(9,854)	(12,106)	(17,113)	(25,241)	(23,825)	(46,698)
Feed purchased ($000)	5,778	2,577	2,993	4,124	6,450	6,377	12,136
	(13,945)	(4,146)	(5,061)	(7,359)	(13,295)	(13,240)	(25,598)
Livestock purchased ($000)	6,069	2,706	4,059	5,793	6,325	7,095	10,504
	(20,335)	(7,663)	(11,994)	(17,345)	(19,086)	(22,399)	(32,950)
On-farm labor measures							
Hired farm labor expenses ($000)	3,183	1,206	1,519	2,484	3,474	4,312	6,084
	(4,462)	(1,119)	(1,482)	(2,722)	(3,985)	(5,004)	(7,115)
Total net income including corporate farms ($000)	7,324	2,043	5,100	8,760	9,465	4,102	14,386
	(15,789)	(3,032)	(6,967)	(11,228)	(15,936)	(15,786)	(26,512)
Total net farm proprietors' income ($000)	5,551	1,942	4,588	7,425	7,667	2,900	8,775
	(11,133)	(2,864)	(6,321)	(9,031)	(12,502)	(11,192)	(17,121)
Off-farm and overall labor measures							
Nonfarm personal income ($000)	448,721	131,078	197,806	325,673	460,316	635,521	922,794
	(713,325)	(154,409)	(240,166)	(393,309)	(565,009)	(793,124)	(1,183,303)
Nonfarm proprietors' income ($000)	30,267	8,859	14,546	22,524	31,893	39,449	63,065
	(56,369)	(10,617)	(17,444)	(28,993)	(44,496)	(58,649)	(101,290)
Total employment	15,266	12,856	13,455	14,714	16,099	16,618	17,724
	(19,008)	(14,943)	(16,187)	(17,721)	(19,840)	(20,827)	(22,729)

Notes: Standard errors shown in parentheses. All dollar values are in real 2007 dollars.

Table 2: Summary Statistics. Changes in Variables Over Time

	Time period					
	Overall	**1982-1987**	**1982-1992**	**1992-1997**	**1997-2002**	**2002-2007**
Number of observations	6,290	1,225	1,278	1,227	1,280	1,280
Hogs (number of head)	1,692	395	1,398	4,001	287	2,419
	(27,381)	(9,259)	(23,406)	(51,565)	(15,735)	(15,869)
Measures of hog production outcomes						
Cash receipts from livestock and products ($000)	7,058	3,876	5,817	5,528	1,767	18,103
	(20,697)	(8,419)	(13,989)	(19,234)	(12,746)	(34,095)
Major upstream industry measures						
Cash receipts from crops ($000)	5,496	1,365	4,511	6,562	-2,237	17,073
	(14,453)	(3,744)	(6,016)	(10,010)	(7,289)	(24,733)
Feed purchased ($000)	1,955	407	1,117	2,467	-73	5,802
	(7,785)	(1,779)	(3,173)	(7,093)	(3,512)	(14,195)
Livestock purchased ($000)	1,577	1,381	1,765	545	747	3,403
	(7,667)	(5,343)	(6,848)	(6,172)	(6,395)	(11,526)
On-farm labor measures						
Hired farm labor expenses ($000)	984	311	971	989	845	1,768
	(1,725)	(590)	(1,413)	(1,636)	(1,382)	(2,595)
Total net income including corporate farms ($000)	2,576	2,953	3,718	1,233	-5,409	10,338
	(13,213)	(5,759)	(7,750)	(8,730)	(13,212)	(19,656)
Total net farm proprietors' income ($000)	1,419	2,517	2,845	645	-4,768	5,875
	(9,820)	(5,117)	(6,165)	(6,944)	(10,717)	(13,716)
Off-farm and overall labor measures						
Nonfarm personal income ($000)	161,940	71,415	123,380	146,230	175,204	287,273
	(250,385)	(92,256)	(153,723)	(180,358)	(234,102)	(404,376)
Nonfarm proprietors' income ($000)	11,082	5,995	7,689	10,151	7,555	23,616
	(26,937)	(8,250)	(12,517)	(18,403)	(24,269)	(46,935)
Total employment	1,040	884	984	1,728	519	1,106
	(2,368)	(2,336)	(1,989)	(2,676)	(1,935)	(2,640)

Notes: Standard errors shown in parentheses. All dollar values are in real 2007 dollars. Unit of observations is the county-time period (for the "Overall" measures) and county for the statistics for individual time periods. Metropolitan counties excluded from all statistics. Sample does not include Alaska, Hawaii, or the Consolidated Cities of Virginia.

Table 3: Regression Results of Main Specification

Coefficient on change in hogs shown.		(i)	(ii)	(iii)	(iv)
	Time frame:	**1982-2007**	**1982-2007**	**1982-1992**	**1997-2007**
Dependent variable: Changes in…	**Sample:**	**Full**	**Full minus top and bottom 1%**	**Full minus top and bottom 1%**	**Full minus top and bottom 1%**
Measures of hog production outcomes					
Cash receipts from livestock and products ($000)		0.289***	0.376***	0.153***	0.639***
		(0.0156)	(0.0477)	(0.0429)	(0.130)
Major upstream industry measures					
Cash receipts from crops ($000)		0.0299***	0.112***	0.0456*	0.245***
		(0.00965)	(0.0223)	(0.0268)	(0.0503)
Feed purchased ($000)		0.0913***	0.111***	0.0550***	0.148***
		(0.00749)	(0.0164)	(0.0135)	(0.0417)
Livestock purchased ($000)		0.0722***	0.101***	0.0265	0.249***
		(0.00350)	(0.0208)	(0.0217)	(0.0554)
On-farm labor measures					
Hired farm labor expenses ($000)		0.0110***	0.0143***	0.00690	0.0199**
		(0.00236)	(0.00321)	(0.00488)	(0.00840)
Total net income including corporate farms ($000)		0.108***	0.160***	0.0262	0.255***
		(0.00841)	(0.0273)	(0.0277)	(0.0827)
Total net farm proprietors' income ($000)		0.0706***	0.111***	0.0102	0.158**
		(0.00406)	(0.0208)	(0.0244)	(0.0620)
Total farm labor and proprietors' income ($000)		0.0792***	0.122***	0.0154	0.170***
		(0.00415)	(0.0200)	(0.0257)	(0.0592)
Off-farm and overall labor measures					
Nonfarm personal income ($000)		0.109**	-0.252	-0.363	0.0576
		(0.0483)	(0.258)	(0.383)	(0.583)
Nonfarm proprietors' income ($000)		0.00552	-0.0154	-0.0610**	0.0169
		(0.00378)	(0.0200)	(0.0268)	(0.0501)
Total employment		0.00193**	-0.00131	-0.00653	0.00523
		(0.000774)	(0.00328)	(0.00857)	(0.00586)

Notes: Standard errors clustered at the level of the county shown in parentheses. All dollar values are in real 2007 dollars. Results of 56 regressions shown. All regressions control for county- and time-varying population density and median home income in the period's start year and state-year fixed effects. *** refers to significance at the 1% level, ** refers to significance at the 5% level, and * refers to significance at the 10% level.

Table 4: Instrumental Variables Regression Results

Coefficient on change in hogs shown.	(i)	(ii)		(iii)	(iv)	(v)		(vi)
	Full Sample				**Removing biggest increases and decreases**			
Dependent variable: Changes in…	**Main Specification**	**Instrumented Hogs**		**Test stats. (see notes)**	**Main Specification**	**Instrumented Hogs**		**Test stats. (see notes)**
Measures of hog production outcomes ($000)								
Cash receipts from livestock and products	0.289***	0.378***	F:	2,063	0.376***	0.758	F:	442
	(0.0156)	(0.0441)	p:	0.267	(0.0477)	(0.663)	p:	0.535
Major upstream industry measures ($000)								
Cash receipts from crops	0.0299***	0.0533***	F:	2,047	0.112***	0.294**	F:	438
	(0.00965)	(0.0147)	p:	0.018	(0.0223)	(0.127)	p:	0.048
Feed purchased	0.0913***	0.0759***	F:	2,005	0.111***	-0.0995	F:	429
	(0.00749)	(0.0174)	p:	0.142	(0.0164)	(0.114)	p:	0.007
Livestock purchased	0.0722***	0.0805***	F:	1,996	0.101***	0.0876	F:	425
	(0.00350)	(0.0148)	p:	0.667	(0.0208)	(0.130)	p:	0.903
On-farm labor measures ($000)								
Hired farm labor expenses	0.0110***	0.00312	F:	2,035	0.0143***	-0.0364	F:	435
	(0.00236)	(0.00279)	p:	0.018	(0.00321)	(0.0387)	p:	0.077
Total net income including corporate farms	0.108***	0.249***	F:	2,034	0.160***	1.109	F:	435
	(0.00841)	(0.0301)	p:	0.088	(0.0273)	(0.855)	p:	0.155
Total net farm proprietors' income	0.0706***	0.204***	F:	2,068	0.111***	0.909	F:	443
	(0.00406)	(0.0176)	p:	0.044	(0.0208)	(0.693)	p:	0.133
Total net farm proprietors' income plus labor expenditures	0.0792***	0.202***	F:	2,068	0.122***	0.871	F:	443
	(0.00415)	(0.0174)	p:	0.049	(0.0200)	(0.656)	p:	0.138
Off-farm and overall labor measures								
Nonfarm personal income ($000)	0.109**	0.0427	F:	2,047	-0.252	-0.472	F:	438
	(0.0483)	(0.0822)	p:	0.457	(0.258)	(1.022)	p:	0.792
Nonfarm proprietors' income ($000)	0.00552	-0.00289	F:	2,017	-0.0154	-0.132	F:	438
	(0.00378)	(0.0194)	p:	0.678	(0.0200)	(0.210)	p:	0.530
Total employment	0.00193**	0.00149	F:	2,047	-0.00131	-0.00660	F:	438
	(0.000774)	(0.00156)	p:	0.733	(0.00328)	(0.0146)	p:	0.703

Notes: Standard errors clustered at the level of the county shown in parentheses. All dollar values are in real 2007 dollars. Results of 44 regressions shown. All regressions control for county- and time-varying population density and median home income in the period's start year and state-year fixed effects. *** refers to significance at the 1% level, ** refers to significance at the 5% level, and * refers to significance at the 10% level. The statistic labeled “F” is the F-value from a test of the joint significance of the instruments in the first stage regression; it is large enough to rule out significant weak instrument bias in all cases. “p” is the p-value from a test of the hypothesis that the instrumented results are the same as the non-instrumented results, i.e. the hypothesis that the endogenous regressor is not in fact endogenous.

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