Journal of Agricultural and Applied Economics, 45,1(February 2013):139–158

The Effects of Large-Scale Hog Production on Local Labor Markets

Stacy Sneeringer and Tom Hertz

Although the negative externalities of large-scale hog production have been well studied, econometric estimates of its potentially positive labor markets effects are lacking. We use the geographic shifts in large-scale hog production between 1992 and 2007 to estimate such production's effects on local farm and nonfarm labor markets. We find that every additional 1000 head at large-scale facilities in a county generates 0.57 additional large-scale hog operation jobs, 0.04 fewer small-scale hog operation jobs, 0.16 fewer nonhog-related agricultural jobs, and 0.59 additional nonfarm jobs, for a total of 0.96 jobs. Our total estimate is lower than previous ones based on input–output modeling.

Key Words: employment, income, hogs

JEL Classification: Q5

Large-scale livestock operations represent a leap forward in agricultural productivity but have been met with considerable opposition in many communities. In addition to aesthetic concerns, opponents cite a growing body of research that finds negative effects of such operations on public health, the environment, and property values (Donham, 2000; Palmquist, Roka, and Vukina, 1997; Sneeringer, 2009a, 2009b, 2010; Thu et al., 1997; Wing and Wolf, 2000). On the other hand, state and local policymakers emphasize the importance of large-scale hog production to regional employment, income, and tax revenues. Some communities have opposed increased environmental regulations that would discourage large-scale hog farms from operating in their jurisdictions,[1] whereas others have encouraged the entry of these operations through tax breaks and welcoming legislation (North Central Regional Center for Rural Development, 1999; Pew Charitable Trusts and Johns Hopkins Bloomberg School of Public Health, undated; Sanders, 2007).

Local policymakers considering the relative merits of welcoming large-scale hog production need sound empirical estimates of its local labor market impact. Although prior studies, reviewed subsequently, have examined this issue using input–output modeling, we were not able to locate any estimates that were based on the retrospective econometric analysis of the labor market experiences of counties in which large-scale hog-farming operations have

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The views expressed are the authors' and do not necessarily reflect those of the Economic Research Service or the USDA.

We thank the editor and three anonymous reviewers for comments.

[1] For example, a group of lawmakers held a hearing in Washington, DC, in September 2010, entitled "The EPA's Assault of Rural America: How New Regulations and Proposed Legislation are Stifling Job Creation and Economic Growth" (Rural America Solutions Group, 2010).

been established; in this article, we present one such set of estimates. We use U.S. Census of Agriculture data from 1992–2007 to quantify the number of hogs at large-scale[2] operations located in nonmetropolitan counties and then exploit the geographic shifts in such production over time to identify its effects on county-level farm and nonfarm employment and earnings.

We find that each additional 1000 head in inventory at large operations generates 0.57 additional jobs on large hog operations, 0.04 fewer jobs on smaller hog farms, and 0.16 fewer jobs on nonhog agricultural operations. Another 0.59 jobs are estimated to be generated in that county's nonfarm economy, largely in wage and salary employment. The total employment impact of hog farming is thus on the order of 0.96 jobs per 1000 hogs in inventory. These are "same-county" estimates, which reflect only the jobs that are generated in the county in which the large-scale production is located. Our total employment estimate is lower than previous estimates based on input–output modeling.

Implications for Local Labor Markets of Structural Change in Hog Production

In the past 15 years, the number of agricultural operations with hogs has fallen by 61% but the average size of such operations has expanded by a factor of three. In 1992 the continental United States held just over 191,000 hog farms with inventories totaling 57.6 million head for an average of 301 hogs per farm. In 2007, the numbers were 63,450 farms with 65 million head, or 1032 hogs per farm. The number of hogs at facilities with over 2500 head has increased by 16% per year, whereas the number at smaller farms decreased by 5% per year. As a result of these offsetting trends, the total number of hogs in inventory in the United States has grown only modestly over time, on average 1.2% per year between 1992 and 2007.[3]

This growth in scale of operations has coincided with a higher degree of specialization, allowing greater productivity. Operations that specialize in feeding hogs that have already been weaned and partially raised (called "feeder-to-finish" operations, as opposed to the more traditional "farrow-to-finish" operations) constituted 22% of all hog enterprises in 1992, rising to 77% in 2004 (Key and McBride, 2007). For both feeder-to-finish and farrow-to-finish production models, larger operations have lower costs. Based on nationally representative survey data from 2004, McBride and Key's (2007) estimates suggest that large (2000–4999 head) and very large (5000 or more head) hog operations employ on average between 0.23 and 1.16 full-time job equivalents per 1000 head in inventory.[4] They document (p. 19) that the largest farms (5000 head or more) required 86–92% fewer hours of labor per hundred pounds of weight gained than did farms in the smallest category (those with fewer than 500 hogs). Large-scale hog operations thus employ fewer people per 1000 head than the smaller operations that they are replacing. McBride and Key also note that the largest operations spent 14–29% less on feed per hundred-weight gain. Lower payments to employment in hog production and its supporting industries should in turn translate into less employment induced in the communities where these employees live and shop.

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[2] We define "large" as an operation having 2500 hogs or more, following Environmental Protection Agency permitting categories.

[3] Authors' calculations using 1992 and 2007 Census of Agriculture data; also see Sneeringer and Hertz (2012) Appendix Figures A1 and A2.

[4] McBride and Key (2007) provide estimates of the average sale weight of a marketed hog for farrow-to-finish and feeder-to-finish production types. For farrow-to-finish operations, we treat this as a measure of weight gain, whereas for feeder-to-finish farms, we subtract 50 pounds as the initial weight of the feeder pigs. We then multiply this by McBride and Key's estimated hours of labor required per hundred-weight gain to arrive at hours of labor per marketed hog. We next multiply this by McBride and Key's estimate of marketed hogs per head of capacity (inventory), $\times$ 1000, to get an estimate of hours of labor per 1000 hogs in inventory. Finally, we divide $\times$ 2200 to convert labor hours to full-time job equivalents. This results in 0.23 full-time job equivalents per 1000 head in inventory for very large (5000 or more head) feeder-to-finish operations and 1.16 full-time job equivalents per head for large (2000–4999 head) farrow-to-finish operations.

Although the reduced labor and input requirements on these larger farms is well established, the possibility that production on large operations might displace production on smaller hog farms at the local level is less well understood. On a market-wide basis, large-scale producers have lower per-unit operating costs and are therefore able to underbid smaller, less efficient farms. This may lead to smaller operations exiting farming, discontinuing hog production (while continuing in other commodities), or expanding (Benjamin, 1996; Ejimakor, 2006). Although market forces may simultaneously yield decreasing numbers of small farms and increasing numbers of large farms in an individual locality, this may not be the result of a local mechanism. Buyers of marketed hogs may compare prices nationally vs. locally, particularly in the context of increasingly vertically integrated production. If the shift to larger facilities is a market-wide phenomenon without local features, then vicinities with increasing large-scale production may not be any more likely to lose smaller-scale farms. However, the literature does not examine the effects of a large-scale facility's local entry on the smaller farms in the vicinity and, as such, this remains a question.

Large-scale hog production will affect employment not just at swine facilities, but also in connected industries. The number of jobs generated locally in upstream and downstream industries by large-scale hog facilities depends on the share of labor and other inputs that are purchased within the same locality as the hog production. Survey evidence indicates that large farrow-to-finish operations buy a smaller share of many inputs in local markets (Abeles-Alison and Connor, 1990; Lazarus, Platas, and Morse, 2002a). This may be the result of the fact that large-scale producers are more likely to have production contracts (McBride and Key, 2007), under which integrators provide feed, technical assistance, and supplies to contractees who raise the hogs. Contractors may be less likely to purchase inputs in the same county as the contractee's farm compared with the traditional independent producers. On the other hand, some counties in which contractors base feed mills and other facilities may display greater production and sale of inputs and greater levels of employment in these industries than county hog inventories would suggest. Finally, the profits accruing to nonlocal contractors may be less likely to be respent locally compared with traditional proprietors' income.

In addition to these structural and organizational shifts, the industry has also seen geographic changes. Increasing disaggregation of crop and livestock agriculture, coupled with lower land requirements and improved indoor production efficiency, has permitted hog production to move to new areas. Although still largely focused in the Cornbelt, hog production has made inroads in the Southeastern seaboard as well as in some Western and Mountain states (see Figure 1).

For our econometric analysis, it is important to understand what factors help determine these geographic shifts in hog production. 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, and historical experience with chicken production are important factors entering into location decisions (Abdallah, Lanyon, and Hallberg, 1995; MacDonald et al., 1999; Rhodes, 1995; Steelman, Page, and Burton, 2004; Stirm and St. Pierre, 2003). Research suggests that other factors typically associated with hog production such as proximity to feed and processing facilities have become less important as transportation costs have declined (Roe, Irwin, and Sharp, 2002). Processing facilities (slaughterhouses) may or may not be present before the arrival of hog facilities and may even be built in response to or in conjunction with large-scale operations.[5]

[5] Roe, Irwin, and Sharp (2002) test whether the growth in the number of hogs in a county between 1992 and 1997 is correlated with 1992 levels measuring proximity to slaughter facilities. They find negative and statistically significant associations between the number of processing facilities within a 500-mile radius of the county and its change in hog inventories. The only statistically significant and positive association they find between processing facility or capacity in the "start" year and subsequent hog inventory growth is for North Carolina. The largest processing facility in the world opened in this state in 1993, right after the state relaxed its environmental and zoning laws for hog production and many large production facilities moved in (see Sneeringer, 2009b).

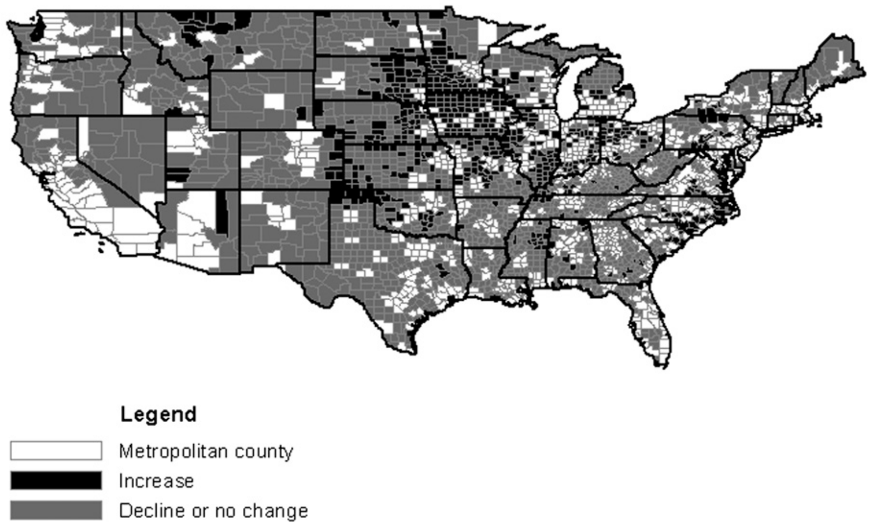

Figure 1. Changes in Number of Hogs at Large Operations in Nonmetropolitan Counties, 1982–2007

Importantly, local labor market conditions are not cited as important determinants of these location decisions, which follows from the low and falling share of labor in total costs.

Also influential in location decisions of livestock producers are incentives in the form of state and local tax breaks and welcoming legislation (Pew Charitable Trusts and Johns Hopkins Bloomberg School of Public Health, undated; Sneeringer, 2009b, 2010). For example, in 1991 Oklahoma relaxed its anticorporate farming laws while the state's Panhandle counties adopted a number of tax breaks and special agreements. This precipitated an 800% increase in the number of hogs in the region 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 argued to have been brought about by a welcoming regulatory and tax environment (Sneeringer, 2009b ; Stith, Warrick, and Sill, 1995).

Prior Research

Existing estimates of the employment effects of hog production have largely been generated using input–output analysis, frequently using IMPLAN software (Minnesota IMPLAN Group, 1999). Input–output models simulate the effects of the expansion of production in a given industry on the jobs created in that industry, those created in upstream suppliers to the industry, and employment created to meet the demand generated by the respending of this labor income.[6] To estimate these effects, input–output models require 1) parameters of the production function for each industry; 2) parameters of the share of expenditures on each input that is paid to suppliers in the region; and 3) parameters of the share of the additional labor income that is respent within the region. The employment estimates from input–output studies differ based on the parameters used in analysis, the spatial extent of the unit of analysis (i.e., state vs. county), the specific location under study, and the method by which indirect

[6] Input–output modelers would refer to these classes of employment as direct, indirect, and induced (respectively). In our analysis, we generally cannot distinguish between indirect and induced employment associated with changes in large-scale hog production. Therefore, we avoid using these terms in our analysis.

employment effects are attributed to particular localities.

Otto and Kliebenstein (1999) use an IMPLAN-based approach to estimate the labor market effects of hog production for 100 Iowa counties and for the state as a whole, covering hog operations of all sizes (not solely large-scale operations). At the statewide level, their estimates equate to 1.2 hog farm full-time job equivalents per 1000 head in inventory; 0.6 full-time job equivalents created in the rest of agriculture per 1000 head; and 4.1 full-time job equivalents per 1000 head generated in all other industries for an Iowa state total of 5.9 full-time job equivalents per 1000 head in inventory. Otto and Kleibenstein then produce county-specific estimates that range between 3.2 and 10.8 total full-time job equivalents per 1000 head in inventory. These represent the estimated share of total statewide hog-related employment that is captured by each county.

Other reports provide further IMPLAN-based estimates of the effect of hog production in individual counties and states. Mayen and McNamara (undated) estimate there are 4.1 total jobs (0.9 hog production and 3.2 additional) per 1000 hogs in the state of Indiana. Kim, Goldsmith, and Thomas (2010) find that Craven County, North Carolina's hog production generates 4.0 jobs per 1000 head in inventory, consisting of 3.0 jobs in hog production and 1.0 additional job. They note that not all of the non-hog production jobs associated with hog production will be created in the same county as the hog production.

Lazarus et al. (2002b) are explicitly concerned with estimating the employment spurred by hog production in the same county as the hog production. They use a modified IMPLAN model to estimate employment attributable to hog production in three Minnesota counties. They produce separate estimates for small vs. large-scale operations and begin with operation type-specific estimates of the inputs needed for hog production rather than rely on IMPLAN's production function parameters for the national hog industry. They then conduct a survey to calculate the share of certain inputs that are purchased locally for each of the counties of analysis. These are used to update the IMPLAN model's parameters, thus improving the accuracy of the estimated share of economic benefits that will be captured by the county in which the hog operation is located. They estimate that between 1.8 and 2.9 total jobs are created per 1000 hogs at large operations (between 0.3 and 1.0 jobs at hog facilities plus 0.8–2.3 additional jobs)[7]; these jobs are in the same county as the large-scale hog operations. Their same-county estimates for these individual counties are 23–53% lower than their corresponding statewide estimates for each operation type.

Lazarus, Platas, and Morse (2002a) extend this work to determine the sensitivity of IMPLAN results to different assumed values of the parameters identifying the share of inputs purchased locally and to the specification of the hog operation production function. They find that both are highly influential and may vary considerably across regions and by scale of operations. IMPLAN estimates are also very sensitive to assumptions about the share of new employment income that is respent locally, which in turn depends in part on whether the workers are local or commuters (Minnesota IMPLAN Group, 1999). This is particularly important when the region is defined as the county rather than the state.

Instead of using an input–output model, we use an econometric analysis of retrospective data to estimate the effects of changes in large-scale hog production in a county on employment in that same county. Because of this methodological difference as well as certain other dissimilarities in assumptions, our results may diverge from prior estimates. For example, inputs per unit of output are lower at large-scale vs. smaller-scale facilities; thus, production function parameters should differ between the two scales of production. Therefore, estimates

[7] These estimates are based on Lazarus et al. (2002b), Table 5, which shows the effects of an assumed output of $40 million. Results were then adjusted up or down to reflect the county's actual output and expressed in terms of jobs per 1000 head in inventory using the state- and county-level output and inventory data from the 1997 Agricultural Census. We report the results for "large farrow-finish" and "large finish and large sow unit" operations.

using all hog production should be larger than our own, which focus only on large-scale production.

Another key contributor to differences between IMPLAN-based estimates and those generated econometrically may be in the method of assigning locations to the jobs and income in supporting industries and the larger economy. As we have seen, some analyses calculate statewide totals for employment and then assign each county a share of this total. By contrast, our method will capture only the employment that is generated in the same county as the hog operation itself. These "same-county" employment estimates should be smaller than those that allocate total statewide hog-related employment across counties.

A third difference between our econometric analysis and input–output models is that our approach can determine whether large-scale hog production reduces employment in other areas of the economy. Large-scale hog production may displace employment in small-scale production and may even have negative effects on agricultural operations outside of hog production. Researchers using input–output models generally do not account for such potential displacement.

A fourth important difference between the two approaches is that input–output modeling assumes that labor supply accommodates the change in labor demand with no effect on wages or any other relative prices. An econometric analysis makes no such assumption and thus can in principle capture the employment and income effects of changes in labor supply and in the factor proportions used in all production processes that are affected by the growth of large-scale hog operations.

Finally, the input–output estimates cited previously focus on specific states or counties, whereas we examine all nonmetropolitan counties in the continental United States. As Lazarus, Platas, and Morse (2002a) point out, the ability of individual counties to capture employment generated by swine production will vary depending on local characteristics (like the presence of supporting industries). Our results will reflect averages over all nonmetropolitan counties rather than just the counties that are the focus of specific studies.

Empirical Strategy

Our approach generates econometric, survey-based estimates using observed data on the past experience of all nonmetropolitan counties in the continental United States over a 15-year-period. We estimate the county-level average number of jobs at both large- and small-scale hog farms, at farms that do not produce hogs, and in the nonfarm sector attributable to county-level changes in the number of hogs at large-scale operations, controlling econometrically for factors related to both large-scale production and labor market outcomes. To our knowledge, no similar studies have been published to date.

Our empirical method closely resembles research in labor economics that compares the outcomes in areas receiving a new employer with outcomes in similar areas not receiving the employer. For example, a number of articles estimate the employment effects in places receiving a Wal-Mart compared with similar places that do not (e.g., Artz and Stone, 2006; Basker, 2005; Newmark, Zhang, and Ciccarella, 2005). Other similar research explores the effects of meat-packing and processing facilities (Artz, Orazem, and Otto, 2007) and coal mines (Black, McKinnish, and Sanders, 2005), for example.

Omitted variables are of particular concern as a potential source of bias when estimating the effects of changes induced by an industry moving into or out of an area. Suppose a large hog operation chooses to locate or expand in an area based on its low population density, and population density also plays a part in nonfarm income (e.g., if salaries in more densely populated places are higher to compensate for higher housing costs). If one then estimates the association between the operation's presence and nonfarm income level without accounting for population density, the resulting coefficients will partially reflect the association between population density and nonfarm income level rather than just the association between the operation's presence and nonfarm income level.

The most straightforward method of confronting potential omitted variables bias is to assess what factors relate both to a large hog operation's presence in the area as well as the outcome variable and then control for these factors in the regression specification. As described previously, the prior literature suggests that large hog operation location decisions are motivated by land prices, population density, climate, historical geographic characteristics, and state-level regulations. Proximity to processing facilities and feed mills are also frequently mentioned as geographic correlates to hog production. All of these factors may also be correlated to different degrees with labor market outcomes.

To estimate effects on labor market outcomes, we use a regression strategy that accounts for these various determinants by including relevant time- and county-varying factors in our equation; using county-level differencing 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 farming; and including state–year fixed effects to account for factors that affect all counties within a state in a specific year (such as state-level regulatory environment and prices). Using county–year observations, we regress the change in the pertinent labor market outcome variable per person on the change in hog inventories at large operations per person. The estimating equation is:

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

Here, ΔY_{cst} and ΔH_{cst} refer to the changes between t and t + 1 in county c and state s in the outcome per person (Y) and the number of hogs at large farms per person (H), respectively. ΔX_{cst} contains changes in the relevant county- and time-varying covariates between times t and t + 1. These include population density, median home price (a proxy for land value), the poverty rate, the percentage of the county population older than aged 25 years with less than 9 years of schooling, the percentage of the county that is black, and the percentage of the county older than age 65 years.[8] $State_s$ and $Year_t$ are vectors of state and year indicator variables, respectively. Interacting these two vectors creates state–year fixed effects, which control for anything that varies over time at the state level; inclusion of these dummy variables means that we are using only within-state–time variation to estimate effects.

Expressing outcomes on a per-capita basis is a standard technique in county-level analysis; it serves to reduce the influence of the largest counties, which can display very large employment changes (Newmark, Zhang, and Ciccarella, 2005). Because both the outcome variables and the hog inventory variable are scaled to population, the coefficient associated with hog inventories (λ) may be interpreted as the effect of 1000 additional hogs at a large farm on the level of the outcome variable.[9] However, the per-capita transformation introduces a known form of heteroscedasticity, because per-capita employment and earnings are more precisely estimated in larger counties than in smaller counties. We correct for this using the standard weighted least squares approach, weighting the data by population size in all regressions (Wooldridge, 2009).

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[8] When estimating effects on the farm outcomes, we performed a robustness check that includes regression covariates for the percentages of county employment in meat processing and at feed mills. Results are very similar to those shown in the main text. See Sneeringer and Hertz (2012) Appendix C, Tables C7 through C10, for a description of these variables as well as results. Because meat processing and feed mill employment measures are part of nonfarm employment, we do not perform a similar robustness check that controls for these variables when estimating the effects of large-scale hog production on nonfarm outcomes.

[9] Dividing both the outcome variable and the variable of interest by population could create a spurious correlation resulting in a biased estimate of λ. However, results are robust to dividing by the constant level of population in 2000 (the middle of the sample period) (see Sneeringer and Hertz [2012] Appendix Tables C1 through C4). Additionally, changes in hog inventories at large operations are not statistically significantly associated with changes in population (see Sneeringer and Hertz [2012] Appendix Table B8).

County observations may be correlated within a state and over time, which violates the standard assumption of independence among the error terms and results in invalid estimates of the standard errors of the regression parameters. We address this problem by specifying that our data are clustered at the state level when calculating standard errors. This accounts for spatial autocorrelation across counties within states as well as within counties over time (see Angrist and Pischke [2009] for a discussion of clustering).[10,11]

We examine how four sets of outcome variables vary with changes in the presence of hogs at large-scale facilities. The first and second sets relate to employment and earnings at large-scale and small-scale hog facilities, respectively. The third group of outcomes covers farm earnings and employment that occurs at agricultural facilities that do not focus on hog production. The fourth group covers nonfarm measures. Each set of outcomes differentiates between employment and earnings of self-employed proprietors vs. wage-and-salary workers. This allows us not only to understand the number of jobs and amount of income generated by large-scale hog production, but also the type of jobs and income.

Although the main specification can address many sources of potential omitted variable bias, we may still face another form of bias related to simultaneity. Suppose a large-scale hog operation chooses to locate or expand in an area with declining nonfarm employment to be able to offer lower wages and hence reduce costs. If such a decision occurs systematically, then associations between large-scale hog production and nonfarm employment will partially reflect the effect of nonfarm employment on large-scale hog production rather than isolating that which we desire to estimate, namely, the operation's effect on local nonfarm employment. Likewise, if large-scale facilities move where small-scale facilities are declining, then an estimated negative relationship between small-scale employment and large-scale facilities may reflect this fact rather than large-scale facilities causing a decline in small-scale ones. In terms of nonhog-related agricultural production, increasing crop production could facilitate a welcoming environment for large-scale hog producers, yielding a simultaneity-related overestimate of large-scale swine facilities' effect on agricultural employment outside of hog production.

We perform a test for strict exogeneity in which the number of hogs at large farms in time t + one (in levels) is added to Eq. (1), yielding the following specification:

$$\Delta Y_{cst} = \alpha + \lambda(\Delta H_{cst}) + \eta(H_{cst+1}) + \Delta X'_{cst}\beta + (State_s \times Year_t)'\theta + e_{cst} \quad (2)$$

If the coefficient η is statistically significant, this suggests the presence of endogeneity (see Wooldridge, 2002, p. 285).[12] However, this will not provide an indication of the direction of any bias.

Our estimates of the relation between hog inventories and outcomes on large-scale hog farms themselves are not subject to the concerns regarding endogeneity as a result of reverse causality that apply to our equations predicting other outcomes. With respect to these outcomes, we do not posit a unidirectional causal model whereby a change in hog inventories at large-scale hog farms causes a change in employment on these farms; instead, these two outcomes are

[10] Briefly, clustering allows the error component e_{cst} to be comprised of both a state term (call it v_s) as well as a assumed mean zero county-level error component (call it w_{cst} such that $e_{cst} = v_s + w_{cst}$). Clustering the data at the level of the state recognizes that observations within a state may be correlated (both across counties and over time) and corrects for this when calculating standard errors. Generally, clustering will increase standard errors on regression coefficients. Accounting for both intrastate and over-time correlation by clustering at the state level provides the most conservative (largest) standard errors.

[11] We also perform robustness checks by using unclustered White-corrected standard errors, by clustering the data by county, and by clustering the data by the state–year. Results are similar to those shown in the article. See Sneeringer and Hertz (2012) Appendix Tables C1 through C4.

[12] Note that we are specifically concerned with testing for the presence of simultaneity-based endogeneity; however, this test will detect endogeneity attributable to any reason.

determined simultaneously as farmers make decisions about the scale of production. The parameter estimates that result from our regressions are properly viewed as descriptive statistics describing the relation between the levels of two factors in an overall production function rather than estimates of the underlying structural parameters of that production function.

Data and Summary Statistics

Data on hog operations come from the U.S. Census of Agriculture from 1992, 1997, 2002, and 2007.[13] We access operation-level confidential data only available after approval from the National Agricultural Statistics Service; for further description on obtaining access to this data, see www.agcensus.usda.gov. County-level public-use data do not provide information on many sizes of farms necessary for ascertaining effects of large-scale production and are often censored when it is possible to discern individual operations.

We make two adjustments to the overall sample of agricultural operations. First, we exclude operations having less than $1000 of inflation-adjusted sales. In each year between 1992 and 2007, the Census includes operations with at least $1000 in nominal sales; because this minimum threshold is not adjusted for inflation, the Census contains more small operations over time. We therefore adjust the $1000 threshold for inflation using NASS' "All Agriculture" index for prices received.[14] Our second adjustment to the sample is the exclusion of farmers in predominantly metropolitan counties using the 2003 metropolitan county definition from the Office of Management and Budget. We use the 2003 definition for all years in the study so as to have a balanced panel of counties.

We use the individual farm-level data to create county-level measures on the number of hogs in inventory at large-scale facilities as our primary explanatory variable of interest.[15] We define large-scale facilities according to the Environmental Protection Agency's definition of a "Large Confined Animal Feeding Operation" (or CAFO); generally, this refers to an operation with 2500 head or more in inventory. We define smaller-scale hog operations as those having between 25 and 2499 hogs in inventory. Our cutoff of 25 head arises from the Economic Research Service's standard for excluding farms that raise hogs primarily for their own consumption (Key and McBride, 2007).

To estimate the effects of changes in one type of agriculture (large-scale hog production) on changes in other types (small-scale hog production and nonhog agricultural production), we need to account for the fact that farms can change categories over time. For example, in response to a large-scale hog operation's arrival, a smaller-scale facility may grow to be able to compete. If a small-scale facility becomes a large-scale facility, we would like to characterize the attendant employment effects as belonging entirely to changes at small-scale operations, not as a loss of employment at small farms, offset by a growth in employment at larger farms. To create mutually exclusive farm categories, we match individual farms over a 5-year time period according to a unique identifier on the Census of Agriculture. Thus, we characterize farms that continue between two Censuses according to their category (large-scale hog, small-scale hog, and nonhog) in the start year. We count new entries according to

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[13] See Sneeringer and Hertz (2012) Appendix A for a detailed description of the data sources and variables.

[14] Adjusting the $1000 cutoff for inflation follows BEA procedures; see Bureau of Economic Analysis (2011) and Sneeringer and Hertz (2012) Appendix A.

[15] We characterize the size of farms according to the number of head. However, an individual hog can be very different sizes, and increasing specialization of hog operations means that two different facilities may have the same number of head in inventory but very different totals for pounds of live weight. This is pertinent for regulations but should not affect our estimates as we calculate county-level totals from the individual operation data. To the extent that different stages of hog production are divided into different operations but remain within the same county, county-level estimates of hog production will reflect the same distribution of hog sizes over time. If different types of operations with different labor demands are moving to separate counties, then estimations from Eq. (1) will provide average effects across types of operations.

their category at entry and exits according to their category at exit.[16]

To calculate the number of wage and salary jobs, we use the stated number of persons employed on the farm for 150 days or more during the year and add an additional wage and salary job (a hired manager) if the operation is a nonfamily-held corporation.[17,18] We use the reported expenditures on hired labor as our estimate of farm wage and salary income. Our estimate of farm proprietor income at sole proprietorships, partnerships, and family-held corporations is the total value of production minus expenditures. We estimate the county-level number of farm proprietors as the sum of sole proprietorships, family-held corporations, and two times the number of partnerships.

Wage and salary income at large hog operations is defined as the total wage and salary expenditures at operations with at least 2500 hogs in inventory. However, this will overestimate the wages and salaries earned in hog production because it does not account for diversified operations that produce hogs as well as other commodities. As a robustness check, we calculate adjusted employment and earnings measures for each hog operation by multiplying employment and earnings by the percentage of the operation's total product attributable to hog sales. Results are presented in Sneeringer and Hertz (2012) Appendix Table C5.[19]

Although the Census is mandatory for all farms, there is still nonresponse. Additionally, the labor and expenditure variables are only asked of a 20% sample of farms. County-level totals are created using the NASS-provided weights to adjust for nonresponse when using the full sample or sampling weights when using the 20% sample. The NASS weights allow data users to expand from the number of respondents to the universe of farms.[20]

Data on our nonfarm regional economic outcome variables come from the Regional Economic Information System (REIS), a product of the U.S. Bureau of Economic Analysis (BEA). We use REIS data on county-level measures of nonfarm income and employment for the four Agricultural Census years between 1992 and 2007. We also use the REIS data on all farm income and employment as a robustness check; see Sneeringer and Hertz (2012) Appendix A for a description of the difference between the REIS all-farm measures and those we calculate, and see Sneeringer and Hertz (2012) Appendix Table C6 for results using the REIS all-farm outcome measures.[21]

Poverty rates for 1997, 2002, 2007 come from the U.S. Census's Small Area Income and Poverty Estimates (SAIPE). Rates for 1992 arise from linear extrapolations using the 1990 county-level poverty rates reported in the U.S. Census Summary Tape File 3A (STF3A) and the 1997 SAIPE estimates.

We obtain a measure of property values from the U.S. Census of Population and Housing from 1990 and 2000. We use publicly available measures of county-level median home price (contained on the U.S. Census Summary Tape File 3A) for the two Censuses and create linear extrapolations of median home prices for the Agricultural Census years before 2000 (5-year intervals between 1992 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

[16] See Sneeringer and Hertz (2012) Appendix A for a further description of calculating changes in farm employment according to mutually exclusive farm categories.

[17] Our methods of calculating employment and earning are informed by and follow where possible the BEA's methods of calculating farm employment and income. More detail on our methods and how they compare with the BEA's is found in Sneeringer and Hertz (2012) Appendix A.

[18] The distinctions made for corporate farms facilitate comparability with the REIS data. See Bureau of Economic Analysis (2011) and Sneeringer and Hertz (2012) Appendix A for more detail.

[19] Results are slightly smaller than those presented in the text.

[20] See Sneeringer and Hertz (2012) Appendix A for a description of how we combine weights when matching across Censuses.

[21] Results are very similar to those generated through our estimates and reported in the main body of the article.

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.

As a measure of county education level, we estimate the percentage of the county population older than age 25 years having less than 9 years of schooling. We use the 1990 and 2000 U.S. Census of Population and Housing Summary File 3 and create linear extrapolations between Censuses to estimate measures for 1992, 1997, 2002, and 2007.

For county-level estimates of the proportion of the county that is black and the proportion that is older than age 65 years, we use the U.S. Census of Population and Housing's Age–Sex–Race files, which contain annual between-Census projections by county.

We put dollar values for earnings and home prices into real 2007 numbers using the Bureau of Labor Statistics' National Income and Product Accounts Personal Consumption Expenditure Price Index.

Table 1 provides the county-level average number of hogs at large operations as well as jobs and labor income at these facilities over time for counties with large-scale hog operations. The number of counties with large-scale facilities increases between 1992 and 2007 as does the average number of hogs at such facilities. In accordance with the number of hogs increasing, so do the number of proprietors. Wage and salary employment

Table 1. Characteristics of Nonmetropolitan Counties with Large-Scale Hog Operations Over Time

	Year			
	1992	1997	2002	2007
Number of nonmetropolitan counties	2,015	2,015	2,015	2,015
Number of nonmetropolitan counties with large-scale hog operations	558	628	611	623
County average number of hogs at large-scale operations	20,085	42,675	56,985	70,019
	(61,261)	(121,726)	(145,570)	(158,971)
Employment and earnings at large-scale operations: averages by county				
Wage and salary employment (jobs)	18.18	30.44	34.48	32.45
	(54.02)	(85.67)	(90.40)	(91.02)
Proprietor employment (jobs)	2.74	4.75	5.89	6.93
	(5.06)	(13.16)	(15.29)	(16.23)
Wage and salary earnings (1000 $)	$464	$787	$1,007	$940
	(1,353)	(2,357)	(2,309)	(2,123)
Proprietor earnings (1000 $)	$542	$1,704	$1,343	$3,222
	(1,490)	(5,667)	(5,451)	(9,983)
Employment and earnings at large-scale operations per 1000 hogs at large-scale operations: averages by county				
Wage and salary employment (jobs)	1.01	0.88	0.69	0.58
	(1.04)	(1.62)	(0.96)	(0.82)
Proprietor employment (jobs)	0.20	0.18	0.16	0.16
	(0.17)	(0.15)	(0.14)	(0.14)
Wage and salary earnings ($)	$24	$20	$20	$16
	(27)	(34)	(22)	(23)
Proprietor earnings ($)	$32	$48	$24	$57
	(40)	(88)	(76)	(109)

Notes: Standard deviations in parentheses. "Large-scale" refers to having 2500 head or more. Averages refer to nonmetropolitan counties with large-scale hog operations in that year. All dollar values are in real 2007 dollars. Unit of observation is the county. Metropolitan counties (defined in 2003) excluded. Hawaii, Alaska, and District of Columbia are also excluded.

and earnings appear to rise until 2002 when they decline somewhat. Proprietor earnings do not follow a constant trend; recall that these are defined as the net product and thus are influenced by market prices for pork and input costs.

We also show the county-level large-scale hog operation employment measures per 1000 hogs at large-scale facilities to examine productivity over time. These are calculated by dividing the total county-level number of jobs or earnings on large-scale hog farms by the total number of hogs at large-scale facilities (in thousands). Per-hog employment and wage and salary earnings generally decline over time, suggesting that even among large-scale operations, labor efficiency is increasing.

The levels of the other outcome variables and covariates used in the regression analyses are shown in Tables 2A and 2B. We see decreasing employment at small hog operations and on nonhog agricultural operations over the study period, increasing nonfarm employment and earnings, rising home prices, and increasing population density. The proportion of the population older than age 25 years with fewer than 9 years of schooling declines over time, the proportion of the population that is

Table 2A. County-Level Averages Over Time, All Nonmetropolitan Counties: Employment and Earnings Variables

	Year			
	1992	1997	2002	2007
Small hog operations				
Wage and salary employment (jobs)	16	10	6	4
	(32)	(24)	(18)	(10)
Proprietor employment (jobs)	49	23	11	8
	(91)	(48)	(24)	(18)
Wage and salary earnings (1000 $)	$254	$164	$104	$78
	(487)	(370)	(280)	(204)
Proprietor earnings (1000 $)	$1,689	$1,168	$419	$717
	(4,034)	(3,142)	(1,411)	(2,337)
Nonhog agricultural operations				
Wage and salary employment (jobs)	181	179	167	167
	(257)	(252)	(263)	(291)
Proprietor employment (jobs)	487	465	382	379
	(344)	(325)	(268)	(270)
Wage and salary earnings (1000 $)	$3,113	$3,334	$3,631	$3,905
	(5,090)	(5,663)	(7,138)	(7,498)
Proprietor earnings (1000 $)	$8,387	$9,910	$8,063	$16,106
	(9,078)	(11,684)	(13,031)	(20,899)
Nonfarm				
Wage and salary employment (jobs)	8,111	9,005	9,211	9,550
	(8,634)	(9,591)	(9,960)	(10,503)
Proprietor employment (jobs)	1,773	2,109	2,266	2,754
	(1,739)	(2,038)	(2,325)	(2,947)
Wage and salary earnings (1000 $)	$267,070	$305,158	$348,469	$385,628
	(314,661)	(355,695)	(411,825)	(462,421)
Proprietor earnings (1000 $)	$33,001	$43,482	$51,521	$54,264
	(36,532)	(47,739)	(61,885)	(65,877)

Notes: Standard deviations in parentheses. All dollar values are in real 2007 dollars. Unit of observation is the county. Metropolitan counties (defined in 2003) excluded. Hawaii, Alaska, and District of Columbia also excluded. Nonhog agricultural operations refer to farms with fewer than 25 head in inventory. Small hog operations have between 25 and 2499 head in inventory.

Table 2B. County-Level Averages Over Time, All Nonmetropolitan Counties: Other Variables

	Year			
	1992	1997	2002	2007
Poverty rate (%)	18.19	16.38	15.01	16.42
	(7.71)	(6.43)	(5.70)	(6.43)
Median home price ($)	$66,688	$76,940	$86,362	$89,549
	(32,249)	(38,522)	(45,227)	(48,761)
Population density (number of people per square mile)	36.10	37.84	38.68	39.43
	(37.01)	(38.90)	(40.49)	(42.33)
Proportion of population older than age 25 years with less than 9 years of schooling	0.15	0.12	0.09	0.06
	(0.07)	(0.06)	(0.05)	(0.05)
Proportion of population that is black	0.08	0.08	0.08	0.08
	(0.15)	(0.15)	(0.15)	(0.15)
Proportion of population older than age 65 years	0.16	0.15	0.16	0.17
	(0.05)	(0.05)	(0.04)	(0.04)

Notes: Standard deviations in parentheses. All dollar values are in real 2007 dollars. Unit of observation is the county. Metropolitan counties (defined in 2003) excluded. Hawaii, Alaska, and District of Columbia also excluded.

black remains constant, and the proportion that is older than age 65 years slowly rises.

Results

Before proceeding to the econometric results, we examine summary statistics for counties that ever have large hog farms between 1992 and 2007 compared with those that do not (Tables 3A and 3B). This provides some suggestion of potential confounding factors. Of nonmetropolitan counties, 40% (812) have large hog farms at some point between 1992 and 2007. Examination of the variables suggests cross-sectional features that belie certain priors regarding where large-scale hog farming takes place. First, the number of nonfarm wage and salary jobs is greater and the poverty rate is lower in places with large-scale hog farming; this finding runs contrary to the belief that large-scale hog farming is more likely to occur in places with greater need for employment or with lower wages. The population density of places that have large-scale hog farms is also higher, another feature that runs contrary to priors. The comparison that does accord with beliefs about where large-scale hog farming occurs concern median home values, which are lower in places with large-scale hog farming.

These cross-sectional statistics cannot tell us whether large-scale hog production entered or grew in places with greater wage and salary earnings and employment or if hog production caused wage and employment growth. To address this question, we turn to the econometric results.

The top half of Table 4A shows results examining employment at large-scale operations, whereas the bottom half shows results for small-scale hog operation employment measures. Shown are results from regressing changes in outcomes (per capita) on changes in hogs at large operations (per capita) controlling for time- and county-varying covariates and state–year fixed effects. In this specification, an additional 1000 hogs corresponds to an additional 0.57 jobs on large-scale hog operations, of which 0.55 are in wage and salary employment, whereas 0.02 are operators.[22] A 1000-head increase in large-scale production yields over $38,000 in hog production income, constituted by $22,000 in wage and salary income and $16,000 in proprietor income.

The bottom half of Table 4A shows the correlations between changes in large-scale

[22] Coefficients on time- and county-varying covariates from Tables 4A and 4B are shown in Sneeringer and Hertz (2012) Appendix Tables B1 through B4. The coefficient on the total number of jobs is equal to the sum of the coefficients on wage and salary jobs and proprietor jobs, except for small differences due to rounding.

Table 3A. Cross-sectional Means and Standard Deviations by Whether or Not County Had Large-Scale Hog Operations: Employment and Earnings Variables

	Counties That Ever Have Large-Scale Hog Operations between 1992 and 2007	Counties That Never Have Large-Scale Hog Operations between 1992 and 2007
Number of nonmetropolitan counties	812	1,202
Number of county–year observations	3,248	4,808
Means and standard deviations		
Hogs at operations with 2500 head or more	35,852	0
	(114,082)	—
Small hog farm employment and earnings		
Wage and salary employment (jobs)	19	2
	(31)	(9)
Proprietor employment (jobs)	49	5
	(80)	(11)
Wage and salary earnings (1000 $)	$325	$31
	(498)	(110)
Proprietor earnings (1000 $)	$2,327	$99
	(4,270)	(355)
Agricultural operations with less than 25 head		
Wage and salary employment (jobs)	181	169
	(175)	(313)
Proprietor employment (jobs)	527	361
	(289)	(301)
Wage and salary earnings (1000 $)	$3,616	$3,414
	(4,138)	(7,599)
Proprietor earnings (1000 $)	$15,595	$7,248
	(16,282)	(12,492)
Nonfarm employment and earnings		
Wage and salary employment (jobs)	9,572	8,561
	(9,676)	(9,711)
Proprietor employment (jobs)	2,207	2,238
	(2,026)	(2,519)
Wage and salary earnings (1000 $)	$344,580	$314,382
	(385,848)	(396,774)
Proprietor earnings (1000 $)	$44,747	$46,123
	(45,793)	(60,280)

Notes: Standard deviations in parentheses. The difference in means for each variable is statistically significantly different from zero below the 5% level for all variables except for nonfarm proprietor income and nonfarm proprietor employment. All dollar values are in real 2007 dollars. Metropolitan counties (defined in 2003) excluded. Hawaii, Alaska, and District of Columbia also excluded.

hog production and income and employment at small (25–2500 head) hog operations. These suggest that as large hog production grows in a county, smaller hog facilities decline in number. A 1000-hog increase is correlated with approximately 0.04 fewer jobs at small hog operations. The losses are predominantly from proprietor jobs. Effects on earnings are not statistically significant.

Table 4B shows the effects of changes in large-scale hog production on nonhog farm and nonfarm earnings and income. An additional 1000 hogs at large-scale operations is correlated with 0.16 fewer nonhog farm jobs but nearly $15,000 more in nonhog farm income. This suggests that large-scale hog farming does not generate local nonhog operation agricultural employment, but does spur higher

Table 3B. Cross-sectional Means and Standard Deviations by Whether or Not County Had Large-Scale Hog Operations: Other Variables

	Counties That Ever Have Large-Scale Hog Operations between 1992 and 2007	Counties That Never Have Large-Scale Hog Operations between 1992 and 2007
Poverty rate (%)	14.51	17.85
	(5.46)	(7.12)
Median home value ($)	$75,349	$82,949
	(23,942)	(51,303)
Population density (number of people per square mile)	41.81	35.44
	(38.93)	(40.09)
Proportion of population older than age 25 years with less than 9 years of schooling	0.10	0.11
	(0.06)	(0.07)
Proportion of population that is black	0.07	0.09
	(0.14)	(0.15)
Proportion of population older than age 65 years	0.16	0.16
	(0.05)	(0.04)

Notes: Standard deviations in parentheses. The difference in means for each variable is statistically significantly different from zero below the 5% level for all variables except for nonfarm proprietor income and nonfarm proprietor employment. All dollar values are in real 2007 dollars. Metropolitan counties (defined in 2003) excluded. Hawaii, Alaska, and District of Columbia also excluded.

incomes for the remaining farmers. Effects are largely seen in proprietor and not wage and salary jobs and income.

For nonfarm industries, a 1000-hog increase at large-scale facilities corresponds to 0.59 additional jobs and nearly $19,000 in nonfarm income. The point estimates suggest that these changes largely arise from wage and salary employment and earnings.

Although the Environmental Protection Agency's definition of a "large CAFO" is one way to define "large hog farms," it is may be arbitrary with regard to potential labor market effects. We therefore perform our regressions using two other definitions for "large farms" (results in Sneeringer and Hertz [2012] Appendix Tables B5 and B6). These include farms with 5000 or more head and with 10,000 or more head. The results are very similar to those using the 2500 head and over size category, suggesting that results are robust with respect to the definition of "large."

Turning to potential bias resulting from simultaneity, results of the endogeneity test described by Eq. (2) (see Sneeringer and Hertz [2012] Appendix Table B7) show the presence of endogeneity in the farm-related outcome variables but not the nonfarm outcomes. The significant endogeneity test statistics for the farm-related outcomes mean that we cannot be sure that the expansion of large-scale hog farms is causally responsible for the decline in employment at smaller-scale hog farms and at nonhog farm operations: the causality may run in the other direction. No such uncertainty surrounds the estimates relating to nonfarm employment and earnings. Here the tests provide no evidence to contradict the assertion that growth in inventories at large-scale hog farms creates nonfarm employment in the county.

In Table 5 we summarize our estimates of how many nonlarge hog-facility jobs are generated per large hog facility job and calculate the total employment impact on the average county. Each 1000 head at large-scale hog facilities is correlated with 0.57 more large-scale hog facility, 0.04 fewer smaller-scale hog operation jobs, 0.16 fewer nonhog farm jobs, and 0.59 nonfarm jobs per 1000 hogs for a total of 0.96 additional jobs in a county. The ratio of total jobs to jobs at large-scale facilities in 0.68. Likewise, an additional 1000 hogs at large-scale facilities generates $38,440 in large-scale hog

Table 4A. Regression Results for Effects of Changes in Number of Hogs at Large Operations on Jobs and Earnings at Large and Small Hog Operations

Shown: Coefficient and Standard Error on Change in County-Level Per-Capita Hog Inventory between t and t + 1.

	Dependent Variable: Change in. . .					
	Jobs at Large Hog Operations			Income (1000 $) at Large Hog Operations		
Independent Variable of Interest: Change in. . .	All	Wage and Salary	Proprietor	All	Wage and Salary	Proprietor
Thousands of hogs at large operations	0.568*** (0.0972)	0.552*** (0.101)	0.0163** (0.00774)	38.44*** (4.853)	22.28*** (5.671)	16.16*** (4.882)
State-year fixed effects included?	Yes	Yes	Yes	Yes	Yes	Yes
County- and time-varying covariates included?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6036	6036	6036	6036	6036	6036
R^2	0.198	0.188	0.182	0.258	0.347	0.116
	Dependent Variable: Change in. . .					
	Jobs at Small Hog Operations			Income (1000 $) at Small Hog Operations		
Independent Variable of Interest: Change in. . .	All	Wage and Salary	Proprietor	All	Wage and Salary	Proprietor
Thousands of hogs at large operations	–0.0438*** (0.00969)	–0.0102*** (0.00296)	–0.0336*** (0.00811)	1.206 (0.989)	–0.0348 (0.0569)	1.241 (0.952)
State-year fixed effects included?	Yes	Yes	Yes	Yes	Yes	Yes
County- and time-varying covariates included?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6036	6036	6036	6036	6036	6036
R^2	0.391	0.101	0.505	0.227	0.059	0.223

Notes: Standard errors clustered at the level of the state shown in parentheses. All dollar values are in real 2007 terms. Results of 18 regressions shown. County- and time-varying covariates include change between time t and t + 1 in population density, median home value, poverty rate, percentage of population older than age 25 years with less than 9 years of schooling, percentage of population that is black, and percentage of population older than age 65 years. ***, **, and * refer to significance at the 1%, 5%, and 10% levels, respectively.

facilities earnings, $1206 in small hog farm earnings, $14,580 in nonhog facility agricultural earnings, and $18,830 in nonfarm earnings for a total of $73,056 in county-level income. The ratio of total income generated to that generated at large-scale hog facilities is $0.90.

The total employment impact for the average county that ever had hogs at large-scale operations between 1992 and 2007 is estimated to be 8.1 jobs (including 4.8 at the large hog facility itself). Total earnings for the average county are estimated to have risen by $619,003 as a result of the expansion of large-scale hog operations.

Discussion and Conclusion

Our regression estimates show that local changes in large-scale hog production are correlated with local declines in small-hog production as well as agricultural employment outside of hog production, although the direction of causality in this

Table 4B. Regression Results for Effects of Changes in Number of Hogs at Large Operations on Jobs and Earnings at Nonhog Farm and Nonfarm Operations

Shown: Coefficient and Standard Error on Change in County-Level Per-Capita Hog Inventory between t and t + 1.

	Dependent Variable: Change in. . .					
	Nonhog Farm Jobs			Nonhog Farm Income (1000 $)		
Independent Variable of Interest: Change in. . .	All	Wage and Salary	Proprietor	All	Wage and Salary	Proprietor
Thousands of hogs at large operations	–0.161*** (0.0594)	–0.0197 (0.0554)	–0.141*** (0.0307)	14.58** (7.144)	–0.00646 (0.958)	14.59** (6.873)
State-year fixed effects included?	Yes	Yes	Yes	Yes	Yes	Yes
County- and time-varying covariates included?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6036	6036	6036	6036	6036	6036
R^2	0.297	0.083	0.450	0.222	0.067	0.227
	Dependent Variable: Change in. . .					
	Nonfarm Jobs			Nonfarm Income (1000 $)		
Independent Variable of Interest: Change in. . .	All	Wage and Salary	Proprietor	All	Wage and Salary	Proprietor
Thousands of hogs at large operations	0.592** (0.288)	0.556* (0.304)	0.0363 (0.0623)	18.83** (7.762)	14.75* (8.007)	4.074* (2.045)
State-year fixed effects included?	Yes	Yes	Yes	Yes	Yes	Yes
County- and time-varying covariates included?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6030	6030	6030	6030	6030	6030
R^2	0.446	0.421	0.259	0.342	0.301	0.332

Notes: Standard errors clustered at the level of the state shown in parentheses. All dollar values are in real 2007 terms. Results of 18 regressions shown. County- and time-varying covariates include change between time t and t + 1 in population density, median home value, poverty rate, percentage of population older than age 25 years with less than 9 years of schooling, percentage of population that is black, and percentage of population older than age 65 years. ***, **, and * refer to significance at the 1%, 5%, and 10% levels, respectively.

relationship is unclear. Although most of the gains at large-scale facilities are in wage and salary jobs, most of those lost are in proprietorships. Despite the losses from small-scale hog producers and other nonhog-related agricultural employment, increases in the number of hogs at large-scale facilities are correlated with an increase in net farm employment as a result of the jobs created at large-scale facilities. Total farm earnings at all types of hog and nonhog farms also rise. A test for endogeneity suggests that our estimates of the effects of large-scale hog production on small-scale hog production and other types of agriculture may be biased, although the direction of bias is unclear. Large-scale hog production is also statistically significantly correlated with increases in employment and earnings in the nonfarm sector, and these results do not appear to reflect significant endogeneity bias.

We find that between 1992 and 2007, an additional 1000 hogs at large-scale operations generates 0.57 hog facility jobs, an estimate within the range suggested by nationally representative survey data (McBride and Key, 2007) but below previously cited estimates greater than one from some input–output analyses. We

Table 5. Estimates of County-Level Employment and Income Generated by Large-Scale Hog Facilities

Jobs at large-scale hog operations, per 1000 hogs at large-scale operations	0.57
Jobs at small-scale hog operations, per 1000 hogs at large-scale operations	–0.04
Nonhog agricultural jobs per 1000 hogs at large-scale operations	–0.16
Nonfarms jobs per 1000 hogs at large-scale operations	0.59
Total jobs per 1000 hogs at large-scale operations	0.96
Total number of nonlarge-scale hog operation jobs per job at large-scale hog operations	0.68
Earnings at large-scale hog operations, per 1000 hogs at large-scale operations	$38,440
Earnings at small-scale hog operations, per 1000 hogs at large-scale operations	$1,206
Nonhog agricultural earnings per 1000 hogs at large-scale operations	$14,580
Nonfarm earnings per 1000 hogs at large-scale operations	$18,830
Total jobs per 1000 hogs at large-scale operations	$73,056
Total nonlarge-scale hog operation earnings per dollar at large-scale hog operations	$0.90
Average 5-year county-level increase in large-scale hog operation inventory	8,473
Implied large hog facility jobs	4.8
Implied small hog facility jobs	–0.3
Implied nonhog agricultural jobs	–1.4
Implied nonfarm jobs	5.0
Total jobs	8.1
Implied large hog operation earnings ($)	$325,702
Implied small hog operation earnings ($)	$10,218
Implied nonhog agricultural earnings ($)	$123,536
Implied nonfarm earnings ($)	$159,547
Total earnings	$619,003

Notes: Average 5-year increase in large-scale hog operation inventory is defined for counties that ever have large-scale hog operations between 1992 and 2007.

find that each job generated at a large-scale facility induces 0.68 of an additional job, which is much smaller than the estimates from prior studies. Various possible reasons for this difference between our results and those of prior studies were discussed previously.

We have focused our attentions on the local (county-wide) effects of large-scale hog production with the intent to inform local communities regarding decisions on welcoming or discouraging such facilities. Because of this focus, we design our empirical strategy in such a way that it does not allow us to identify effects that occur outside of the county experiencing the increases in hog production. Thus, if large-scale hog production in one county generates jobs in other counties, we do not capture this.

To provide some sense of the overall number of jobs generated by large-scale hog farms according to our estimates, note that the average (county-level) change in the number of hogs at large operations in a 5-year period between 1992 and 2007 was 8473 (see Table 5). This implies 4.8 additional hog facility, 0.3 fewer small hog facility jobs, 1.4 fewer nonhog agricultural jobs, and 5.0 additional nonfarm jobs as well as $326,000 in large-scale hog facility earnings, $10,000 in small hog farm earnings, $124,000 in nonhog agricultural earnings, and $160,000 in nonfarm earnings. These numbers may be compared with empirically derived estimates of the employment impact of economic growth in other industries as part of a local cost–benefit analysis of hog farming vs. other economic development strategies.

[Received April 2011; Accepted September 2012.]

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