Title: Productivity and Economic Impacts of Feedgrade Antibiotic Use in Pork Production - **NPB #02-094**

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Abstract: Antibiotics have been used in animal production for several decades. Antibiotics are used routinely now in pork production (NAHMS 2000). There is increasing concern about the use of antibiotics in animal production. There is no hard evidence supporting the link of antibiotic use in animals to observations of antibiotic resistant infections in humans. Nonetheless, a careful examination of the value of continued antibiotic use in agricultural, and in pork production, in particular, is warranted. Therefore, our study measures the productivity and economic impacts of antibiotic use for pig producers at the farm level. We use data from the NAHMS 2000 swine survey. We estimate the combined effects from antibiotics used for growth promotion (AGP) and antibiotics used from disease prevention (ADP) on four productivity measures (namely, average daily gain, feed conversion ratio, mortality rate (MR), and lightweight rate (LR)). We also estimate the economic impact of AGP and ADP for individual pork producers. We estimate these four productivity relationships using seemingly unrelated regression analysis. To help understand the economic impact on producers of alternative public policies regarding animal antibiotic use in pork production, we evaluate the impact of a ban on AGP and ADP, and we use a synthetic firm partial budget to estimate these economic impacts.

Our research results show that pig productivity is improved with AGP, but ADP is associated with lower profits since it is correlated with poorer herd health. Producers have higher profits when AGP and ADP are applied at optimal levels. In this case, producers gain $4,146 for each 1,020 head barn compared to no antibiotic use.

Introduction: According to the most recent swine survey conducted by the National Animal Health Monitoring System, 88% of farms used antibiotics, and the most common reason was for growth promotion. Antibiotics are used for multiple purposes and administered in a variety of ways. Antibiotics used for growth promotion (AGP) or antibiotics used for disease prevention (ADP) are often administered at subtherapeutic levels, or in other words, at levels below those which would be used to treat clinical disease.

Objectives: This research develops estimates of the economic contribution of feedgrade antibiotic use in U.S. pork production through an econometric analysis of the 2000 NAHMS Swine Survey data. The distinct contribution of feedgrade antibiotic use on feed conversion ratio, average daily gain, mortality and lightweight rate is estimated. These estimated productivity impacts then serve as parameter inputs in a swine production profitability analysis spreadsheet program in order to ascertain the economic impact on U.S. pork producers from the use of feedgrade antibiotics as an input in their production processes. These objectives meet the pork industry's priorities as identified in the National Pork Board's 2002 Research Solicitation under Section D.1 where it states the need for "analysis of production economics" as impacted by antimicrobial use.

Procedures: Linear regression is used to identify relationships between productivity, antibiotic use, and other potentially relevant factors of production. Average daily gain (ADG) and feed conversion ratio (FCR) serve as the primary productivity measures, and mortality rate and light weight rate serve as additional productivity measures employed. Explanatory variables include measures of antibiotic usage, geographic region, size and type of operation, hygiene practices, disease prevention practices, and illness and disease measures. See Table 1 for a listing of the variables employed in the regression analyses along with summary level descriptive statistics.

The four productivity measures of interest and their relationship to the explanatory variables are treated as a system of seemingly unrelated regression equations, with the equations estimated jointly with the assumption of a correlated error structure. Treating the error terms as being correlated accounts for the likelihood that the unobserved factors of the production process potentially can impact all of the both ADG and FCR. By estimating the models jointly rather than separately, this approach produces parameter estimates that are more efficient. In addition to antibiotic usage variables, explanatory variables in the mortality model will include type of facility, size of operation, herd health and biosecurity measures, disease prevention measures adopted by producers, and geographic region (see Table 1).

The data in this study comes from the 2000 NAHMS National Swine Survey. This survey was designed to provide statistically valid estimates of key parameters relating to the health, management, and productivity of the U.S. swine herd. The National Swine Survey provides measures of mortality, feed conversion ratio, and average daily gain, as well as measures of antibiotic useage (with an emphasis in the 2000 Survey upon decision-making related to animal health) and other production practices. Thus, variables necessary to control for potential confounding influences in the estimation of the impact of the economic contribution of feedgrade antibiotic usage are available.

Results: Estimated coefficients, with associated statistics are presented for each estimated equation in tables 2-5. The SUR system related R-squared is 0.0904. There are fifteen exogenous variables used to explain ADG (table 2). Antibiotics used for growth promotion (AGP) were found to be important determinants of ADG. The effect of AGP depends on the amount of time AGP was fed. ADG was highest when AGP were fed between 61 to 90 days with an increased ADG of 0.09 pounds (5.6% improvement) compared with no AGP. Antibiotics used for disease prevention (ADP) were associated with decreased ADG. The number of different antibiotics used, either for growth promotion or disease prevention, was not significantly related to ADG. Besides antibiotic use variables (AGP and ADP), other explanatory factors contributed to variation in ADG. These variables include enhanced biosecurity by the use of all-in-all-out pig flow (ADG increases by 0.031), and number of restrictive procedures required for entry (ADG increases by 0.012 with each restrictive procedure added). Also, ADG is improved by feeding more rations (ADG increases by 0.055 if 5 or more different rations are used). Contracting with a packer, obtaining a higher percentage of pigs from offsite sources, and increasing the number of vaccinations injected were associated with a lower ADG.

Eleven exogenous variables contribute to the explanation of variation in FCR (table 3). Here we find that ADP was associated with poorer (increased) FCR. The estimated coefficients from ADP suggest FCR improves (decreased FCR) only when ADP are fed for more than 31 days. No effects of AGP on FCR were identified, either in terms of the number of different antibiotics or time AGP was fed. Other factors affecting FCR include total confinement (improves FCR, estimated coefficient = -0.158), all-in all-out pig flow (improves FCR, estimated coefficient = -0.165), use of feed supplements (improves FCR, estimated coefficient = -0.087), and being from the East-Central U.S. (improves FCR, estimated coefficient = -0.10). Some exogenous variables contribute to poorer FCR, although both associations are in the direction anticipated; these include increased number of vaccinations (estimated coefficient = 0.012), and re-sorting pigs after they are placed in the finishing barn (estimated coefficient = 0.027).

With respect to mortality rate, neither AGP or ADP were found to be statistically significant in explaining the variation in the mortality rate (Table 4). However, as expected, using 3 or more antibiotics to treat disease was associated with increased mortality rate, and increased numbers of days of antibiotic treatment were associated with decreased mortality rate. As seen in Table 5, AGP is associated with decreased lightweight rate. The use of AGP from 61 to 90 days had the most improvement in the lightweight rate.

To estimate the potential losses to pork producers under a ban of antibiotics used for growth promotion purposes, a simple partial budget calculation was used to estimate the economic impact for a producer for each 1,020 head pig barn. We use average pig revenues and costs of production data for 1999-2001 (Miller, et al, 2001, University of Illinois, and USDA, NASS). We estimate the influence of a ban on producer profitability by projecting changes in each of the four productivity measurements from the baseline model. The liveweight price received by producers was assumed to be $40.17/cwt. All other variables involved in the estimated model are assumed to take values of the NAHMS 2000 data averages.

We analyze the economic impacts on farm profitability of a ban on AGP and ADP. Our regression results demonstrate that AGP still contributes importantly to improved productivity in swine production. A ban on AGP will decrease ADG from 1.67 to 1.63 and increase LR from 0.021 to 0.036. Producers have higher profits when AGP and ADP are applied at levels where pig productivity is maximized. In this case, producers gain $4,146 for each 1,020 head barn compared to no antibiotic use.

Discussion: With animal growth promotion being a common use and application for antibiotics in pork production, a solid understanding of the benefits is important background information for both producers and for those involved with discussions surrounding antibiotic use practices. While some pork operations function without antibiotics used for growth promotion, this research, which is based on a national survey of pork producers in the year 2000 indicates that, on average, producers using antibiotics in an economically optimal fashion for both growth promotion and disease prevention purposes obtain higher profits compared to no antibiotic use.

Lay Interpretation: An economic and statistical analysis of the 2000 NAHMS National Swine Survey data reveals that efficient use of antibiotics for growth promotion and disease prevention purposes is associated with improved levels of herd productivity measures, such as ADG and FCR. A farm budget analysis, conducted for a 1,020 head finishing barn, illustrates a significant contribution of antibiotic use to profits. When antibiotics for growth promotion and disease prevention purposes are carefully applied at optimal levels, our farm budget analysis indicates that producers gain $4,146 for each 1,020 head barn compared to no antibiotic use.

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Table 1. Variables related to pig productivity: variable names, descriptions, and descriptive statistics*

Variable	Description	Standard deviation	Means/ Proportion
Endogenous variables			
ADG	Average daily gain	0.184	1.672
FCR	Feed conversion ratio	0.384	2.980
LnMR	ln mortality rate	0.658	-3.654
LnLR	ln light weight rate	2.652	-5.817
Antibiotic use variables			
AGP1-30	Growth promotion antibiotic used in feed between 1-30 days (dummy variable)	0.280	0.086
AGP31-60	Growth promotion antibiotic used in feed Between 31-60 days (dummy variable)	0.347	0.140
AGP61-90	Growth promotion antibiotic used in feed between 61-90 days (dummy variable)	0.298	0.098
AGP91-up	Growth promotion antibiotic used in feed more than 91 days (dummy variable)	0.451	0.283
ADP1-30	Disease prevention antibiotic used in feed between 1-30 days (dummy variable)	0.429	0.241
ADP31-up	Disease prevention antibiotic used in feed more than 31 days (dummy variable)	0.425	0.235
dabxnumtreat2-3	2-3 different antibiotics used for treatment (dummy variable)	0.429	0.241
Abxdaytreat	Num. of days antibiotic used for treatment	26.343	15.330
AbxnumGP	Num. of antibiotics used for growth promotion	0.849	0.876
Animal health/disease			
ingredientNum	Num. of ingredient added	1.265	1.517
vetvisitNum	Num. of veterinary visit	0.833	1.254
deathreasonNum	Num. of reasons given for pig death	1.594	3.844
vaccNum	Num. of vaccinations	2.742	3.063
disnumG	Num. of diseases observed in the G/F stage	2.290	3.286
Management			
dcontract	Contract producer (dummy variable)	0.452	0.286
holdingdays	Days in the G/F stage	19.724	114.867
offsite source	Percent of other site	0.193	0.040
Re-sort	Re-sorting (dummy variable)	0.938	0.876
Facility Description			
confinement	Total confinement (dummy variable)	0.414	0.781
Bio-security			
biosecurityNum	Num. of procedures required for entry	2.009	5.187
daiao	All-in-all-out (dummy variable)	0.500	0.533
PreventN2	Num. of prevention practice	1.068	2.530
Rations			
dRation3-4	Using 3-4 different rations (dummy variable)	0.497	0.435

dRation5-up	Using 5 or more different rations (dummy variable)	0.499	0.457
supplNum	Num. of supplements (fish, meat, bone, soybean meal, other protein bakery/food by products and animal or vegetable fat supplements)	1.238	2.327
Environment			
EnvtestNum	Num. of air, water tests	6.698	4.051
Eastcentral	East Central region (Illinois, Indiana Iowa and Ohio) (dummy variable)	0.488	0.387
Northern	Northern region (Michigan, Minnesota, Pennsylvania and Wisconsin) (dummy variable)	0.405	0.206
Westcentral	West central region (Colorado, Kansas, Nebraska, Missouri and South Dakota) (dummy variable)	0.452	0.286

* There are 16 dummy variables among 29 variables

Table 2. Regression results for average daily gain (ADG) in finishing pigs

Variable	Coefficient	SE	t-ratio	P-value
Intercept	1.614	0.051	31.430	<.0001
AGP1-30	0.052	0.039	1.350	0.177
AGP3 1-60	0.062	0.032	1.950	0.052
AGP61-90	0.093	0.037	2.530	0.012
AGP91-up	0.069	0.026	2.680	0.008
ADP1-30	-0.054	0.025	-2.120	0.035
dcontract	-0.047	0.026	-1.810	0.072
daiao	0.031	0.022	1.410	0.159
offsite source	-0.083	0.055	-1.530	0.128
biosecurity Num	0.012	0.005	2.240	0.026
deathreasonNum	-0.015	0.006	-2.310	0.022
ration3-4	0.016	0.035	0.450	0.653
ration5-up	0.055	0.035	1.590	0.113
VaccNum	-0.006	0.004	-1.590	0.112
SupplNum	0.005	0.009	0.610	0.545

Table 3. Regression results for feed conversion ratio (FCR) in finishing pigs

Variable	Coefficient	SE	t-Ratio	P-value
Intercept	3.616	0.092	39.260	<.0001
ADP1-30	0.088	0.048	1.850	0.065
ADP31-up	-0.037	0.047	-0.780	0.435
confinement	-0.158	0.047	-3.380	0.001
daiao	-0.165	0.040	-4.080	<.0001
vaccNum	0.012	0.007	1.650	0.100
biosecuritytNum	-0.037	0.010	-3.690	0.000
supplNum	-0.087	0.016	-5.380	<.0001
dration3-4	-0.063	0.066	-0.950	0.341
dration5-up	-0.078	0.067	-1.170	0.241
re-sort	0.027	0.021	1.280	0.201
Eastcentral	-0.100	0.040	-2.470	0.014

Table 4. Regression results for mortality rate (lnMR) in finishing pigs

Variable	Coefficient	SE	t-Ratio	P-value
Intercept	-4.382	0.274	-15.990	<.0001
dabxnumtreat3_up	0.180	0.160	1.120	0.262
disnumG	0.053	0.016	3.300	0.001
abxdaytreat	-0.003	0.002	-1.640	0.102
vaccNum	0.002	0.013	0.190	0.853
deathreasonNum	0.046	0.023	2.030	0.043
preventN2	0.094	0.033	2.820	0.005
holdingDay	0.003	0.002	1.480	0.140
Re-sort	0.046	0.038	1.230	0.221
Northern	-0.168	0.130	-1.300	0.195
Westcentral	-0.245	0.127	-1.930	0.055
Eastcentral	-0.225	0.119	-1.900	0.059

Table 5. Regression results for ln Lightweight rate (lnLR) in finishing pigs

Variable	Coefficient	SE	t-Ratio	P-value
Intercept	-4.826	0.973	-7.010	<.0001
Abxnum1	0.412	0.290	1.420	0.156
AGP1-30	0.437	0.636	0.690	0.493
AGP31-60	-1.023	0.596	-1.720	0.087
AGP61-90	-1.400	0.644	-2.170	0.031
AGP91-up	-0.889	0.573	-1.550	0.122
dration5-up	0.480	0.289	1.660	0.098
ingredientNum	0.311	0.113	2.740	0.007
envtestNum	0.104	0.021	4.960	<.0001
vetvisitNum	0.428	0.172	2.480	0.014
confinement	0.535	0.344	1.560	0.120
daiao	0.860	0.291	2.950	0.003
dcontract	-0.218	0.338	-0.640	0.520
holdingDay	-0.009	0.007	-1.210	0.226
Re-sort	0.237	0.152	1.550	0.122
Northern	-0.686	0.368	-1.860	0.064
Westcentral	-1.350	0.342	-3.940	0.000