Feed-Grain Consumption by Traditional Pork-Producing Households in China

Cheng Fang and Frank Fuller

Working Paper 98-WP 203
December 1998

Center for Agricultural and Rural Development
Iowa State University
Ames, IA 50011-1070

Cheng Fang is a CARD/FAPRI assistant scientist and Frank Fuller is a CARD/FAPRI associate scientist.

Partial funding for this research was provided by a U.S. Department of Agriculture National Research Initiative Grant, agreement number 97-35400-4595.

For questions or comments about the content of this paper, please contact Frank Fuller, Iowa State University, 571 Heady Hall, Ames, IA 50011-1070; e-mail: ffuller@gcard.iastate.edu; voice, 515-294-0470.

ABSTRACT

Economic reforms in China's agricultural sector initiated in the late 1970s led to rapid structural change in China's pork sector. Swine production units have declined in number but increased in size. Using household survey data from seven provinces in China, feed-grain demand by pork producers is estimated for three different size categories: producers with annual pork output of less than 200 kg, between 200 kg and 500 kg, and greater than 500 kg. The results show that the households slaughtering one or two pigs each year are not market-oriented in their pork production. However, households producing more than 200 kg are quite price-responsive, especially households slaughtering more than five or six hogs each year. Wald tests for structural change indicate there is significant structural change as producers increase their scale of production and rely more heavily on markets for feed inputs.

Feed-Grain Consumption by Traditional Pork-Producing Households in China

Since the rural economic reforms initiated in 1978, economic growth in China has been phenomenal and has led to substantial changes in food consumption patterns. On average, Chinese consumers have decreased their intake of staple food grains and increased consumption of animal products. As rapid economic growth continues in the future, consumption of meat, dairy products, alcohol, and fish will increase in China. These rapid changes in Chinese consumption behavior may have an enormous impact on the world feed-grain market because China must achieve tremendous growth in livestock production using its limited resources for raising the necessary feed grain. With only 9 percent of the world's arable land, efficient use of Chinese agricultural resources favors labor-intensive crops such as vegetables and fruits over feed grains because feed-grain production is land intensive and labor extensive. It has become obvious to many observers that China will need to import feed grains or livestock products to achieve consumer diets similar to those of the developed world (Hayes and Clemens 1997).

China's switch from a net exporter to a net importer of feed grains has enormous implications for U.S. pork producers. The rise of a middle class in China supported by rising real incomes, investment, and employment growth in the coastal provinces is the driving force behind China's growing demand for livestock products. Moreover, the strong commitment of the Chinese government to food security, particularly food grain security, means there is great potential for developing a market for U.S. exports of high-value and high-quality food in China (Wailes, Fang, and Tuan 1998). Whether or not this potential is realized depends on China's trade policy and on its ability to supply its growing demand for livestock products from domestic sources. Though there are many important factors that determine China's productive capacity for livestock products, this paper focuses on the demand for feed grain in China's most important livestock sector, swine production.

Many studies such as Lewis and Andrews (1989), Halbrendt et al. (1994), Fan et al. (1995), and Han et al. (1998) have estimated Chinese food demand. However, the authors know of no attempts to econometrically estimate the feed demand behavior of Chinese pork producers. Most feed demand studies calculate China's feed requirements by multiplying feed conversion coefficients by livestock production levels to obtain a total demand for feed. Examples of this approach are found in studies conducted by the World Bank (1993), Guo et al. (1996), and Carter and Zhong (1991). Simpson, Cheng, and Miyazaki (1994) utilized a more sophisticated version of this approach by converting livestock production into protein and energy demands via fixed conversion factors. The weakness of the fixed-coefficient approach is that feeding practices in China are quite diverse and can vary dramatically from the assumptions that underlie the calculation of standard conversion factors. Moreover, using fixed coefficients to estimate feed demand only incorporates the impact of feed price changes through their effects on livestock production. Substitution among feeds as a result of relative price changes is excluded in a fixed-coefficient analysis. Our lack of knowledge about China's livestock and feed demand relationships is a great weakness in current projections of China's future feed requirements (Fan et al. 1995; Qu 1998).

This study is an initial effort to estimate the price responsiveness of feed demand by pork producers in China. The next section describes traditional production and feeding practices in China's pork sector. A simple econometric model of feed demand is then developed and estimated using cross-sectional data from a rural household survey. The estimation results and the outcome of tests for structural change are presented, and the paper concludes with a brief discussion of the implications of these estimates for China's future feed-grain demand.

Production and Feed Utilization in China's Pork Industry

Pork is a staple meat in Chinese diets, accounting for more than 80 percent of total meat consumption. Swine production is the dominant component of total livestock output in both grazing and farming regions, though beef and mutton play a more important role in grazing regions. Based on data from China's State Statistic Bureau (SSB), total pork production in 1980 amounted to 11.34 mmt. This number increased to 40.38 mmt by 1996, accounting for 51 percent of world pork production.

Prior to 1979, the government rigidly controlled production, marketing, and trade of all major agricultural commodities in China, including pork. Chinese farmers could sell their live animals and livestock products either through the government procurement system or in local rural markets after securing a slaughtering permit. Between 1965 and 1977, the government procured 60 to 66 percent of the total annual hog slaughter, and local market sales were minimal. The pork procurement price increase in 1979 encouraged farmers to sell more meat to the government, and the percentage of production entering government channels rose to a record 69 to 72 percent (Tuan 1987). Most of the balance was slaughtered locally and consumed on the farm.

Corresponding to the two-tiered marketing system, two livestock product prices were important to Chinese swine farmers before 1985: the procurement price for hogs and the retail price of pork. Procurement prices were the prices farmers received from the government when they delivered their animal products to state procurement stations. Procurement prices for pork and other major agricultural commodities were often set at levels below the world market. Moreover, procurement prices did not reflect supply and demand conditions, rather they were determined by the competing goals of increasing rural incomes and providing low-cost food to urban residents. The government price also varied little by season or region, thus failing to direct producers to market their products evenly throughout the year and by region.

In the late 1980s, many provinces began lowering procurement quotas and eliminating or reducing bonuses and grain rewards for selling slaughter hogs at procurement stations. In early 1985 the government abolished the fixed procurement and retail prices for pork, and procurement prices were replaced by contract prices. Farmers without contracts did not have a production quota and could sell hogs without having to go through the government procurement system. Currently in China, market forces determine the price of hogs, and quality-based price differentials are often observed in the marketplace.

The evolution of government procurement polices in the pork sector has influenced the structure of production. The configuration of swine production in China has been changing. Households specializing in pork production and commercial enterprises have historically accounted for only a small percentage of total output. Traditional household or “backyard” producers continue to raise the vast majority of hogs in China. In 1965 backyard producers accounted for 83 percent of total pork production in China. With the dissolution of many collective farms and the institution of the Household Responsibility System (HRS) in the early 1980s, backyard production increased to 92.9 percent in 1982. China’s rapid transition towards a more market-orientated economy in the 1980s and 1990s reduced backyard pork production to 80.7 percent by 1995, as an increasing number of households began specializing in pork production. This trend towards specialized and commercial production is likely to continue as China's agricultural economy continues to modernize.

General economic development has also induced change in China's pork production patterns. Rapid economic growth in China since the latter half of the 1980s created massive employment opportunities in nonagricultural sectors, especially in coastal areas. As a result, many families who had raised pigs as a complementary sideline operation, ceased production. Based on survey data (with the sample of more than 10,000 households) collected by the Research Center for Rural Economy (RCRE) in China's Ministry of Agriculture, the average percentage of rural households raising pigs in China has declined from 60.39 percent in 1986 to 54.49 percent in 1995 (see Table 1). Moreover, the provinces with more rapid development of township enterprises display a larger decrease in the number of households raising pigs. For example, the percentage of rural households raising hogs in Guangdong, Jiangsu, and Zhejing was reduced by 33.4, 23.6, and 19.8 percent, respectively, in the 10 years from 1986 to 1995.

Table 1. Change in the percentage of households raising pigs the major pork-producing provinces

Province	1986	1995	Province	1986	1995
	Percentage			Percentage	
Liaoning	48.37	48.83	Henan	37.50	46.70
Jiangsu	73.20	49.63	Hunan	85.19	87.43
Zhejiang	55.91	36.13	Guandong	79.20	45.73
Anhui	74.69	60.20	Sichuan	83.89	88.53
Shandong	54.37	42.03	Shaanxi	56.70	46.10
Average	**60.39**	**54.49**			

With many part-time swine producers exiting the industry, the average scale of household pork production has increased in China. Table 2 shows the evolution of Chinese household pork production over the last decade. In the past, most hog farmers raised one to two pigs each year. In 1986, 77 percent of the pork produced by traditional households in China was raised on farms with an annual output of less than 200 kg. This figure decreased to 66 percent by 1995. The percentage of backyard farmers with annual pork output of 200 to 500 kg has increased from 21.48 to 27.73 percent, while those with more than 500 kg increased from 1.56 to 6.24 percent during the same period.

Table 2. The change in swine production size

Year	Household Annual Pork Production				
	<100 kg	100-200 kg	200-500 kg	500-1000 kg	>1000 kg
	Percentage of Total Pork Production				
1986	38.11	38.84	21.48	1.42	0.14
1990	32.70	39.88	24.15	2.58	0.70
1995	31.95	34.08	27.73	4.45	1.79

Source: Adopted from Zhang and Lu (1997).

An important characteristic of traditional household pork production is that much of the meat produced is consumed on the farm. As pork production shifts toward specialized and commercial operations, the share of pork entering the marketing chain is increasing. Over the last 25 years, the share of pork production consumed on the farm has decreased from 54 percent to 27 percent (Han and Feng 1992). Expanding the quantity of pork flowing through marketing channels has raised consumer demands for higher quality pork since fewer consumers are eating pork they produce themselves. Furthermore, the abolition of the procurement quotas for pork paved the way for the markets to send price signals to producers that reflect the increased demand for quality meat. Since the pork produced by most traditional households has a higher percentage of fat than pork from specialized households, higher quality standards place many backyard pork producers at a disadvantage in the marketplace.

Traditional pork producers in China have typically exhibited low feeding costs and low net income. "Raising cattle for plowing fields and feeding hogs for fertilizer for crop cultivation" has long been the slogan to explain why Chinese farmers keep cattle and hogs. There has been little emphasis on quality and efficiency, and this is reflected in the feeding practices of small household producers. The quantities and types of feed given to Chinese livestock, particularly hogs, are quite different from those used to feed animals for meat output in western countries. Hogs in China frequently consume large amounts of green roughage such as water plants, vegetable leaves, tubers, carrots, pumpkins, and various crop stalks. Based on data from a survey conducted by the University of Arkansas (UOA) and RCRE[1], green feeds account for 18.5 percent of total feed consumption in backyard hog operations. Grain by-products, such as brans and hulls, are also frequently used in China to feed swine. Meal products made from soybeans, peanuts, cottonseed, rapeseed, fish, cocoons, and bone are used as supplemental sources of protein or minerals. Based on the survey data, by-products from restaurants and manufactured food processes, such as alcohol, tofu, and bean and tuber noodle production, averaged between 2 and 6 percent of total feed in backyard production. The types of grain used for swine feed varies by location in China. Frequently, the primary grain and grain by-products used for feed are derived from the crops grown and processed on the farm. The survey shows that swine rations on backyard farms contain approximately 36.1 percent purchased concentrate feeds, and in some provinces, such as Jilin, Shandong and Shaanxi, the share of concentrates in total feed is less than 20 percent.

As the scale of production increases, swine producers in China place greater emphasis on efficiency and quality in production, and the result is that feed rations and feed utilization change rapidly. Households with higher pork production typically expand their use of mixed feeds and unprocessed feed grain as substitutes for nonconventional and by-product feeds. This growth in high-quality, grain-based feed consumption per kilogram of pork is partially offset by increased feed efficiency. In addition, fewer days are required for hogs to reach slaughter weight on larger farms than on smaller operations (Simpson, Cheng, and Miyazaki 1994).

Model Development and Data

The objective of this study is to estimate the responsiveness of unprocessed feed-grain demand by traditional Chinese pork-producing households to feed price changes. For simplicity and ease of interpretation, a single equation approach is used to estimate the feed demand response. We assume pork production at the household level can be characterized by a linear homogeneous technology summarized via the general cost function.

(1) $$C(y,\mathbf{w},\mathbf{z}) = yc(\mathbf{w},\mathbf{z})$$

where y is pork production, **w** is a vector of input prices, and **z** is a vector of shift variables capturing regional effects and other factors affecting production costs. Using the derivative property of the cost function, we obtain the grain to meat conversion ratio (GCR) as a function of prices and shift variables by differentiating the cost function with respect to the grain price (w_g) and dividing by output. This result forms the basis for the estimated demand equation:

(2) $$\frac{1}{y}\left(\frac{\partial C(y,\mathbf{w},\mathbf{z})}{\partial w_g}\right) = GCR = G(\mathbf{w},\mathbf{z})\,.$$

The data used in the estimation came from the feed consumption survey conducted by the University of Arkansas and RCRE in 1997. The survey included seven provinces (Sichuan, Hunan, Jilin, Shandong, Shaanxi, Guandong, and Jiangsu) to capture a cross-section of the different livestock production practices in China. The total pork production of the provinces surveyed was 14.5 mmt, accounting for 45 percent of China's total pork production in 1996. The survey collected information about each household's annual pork production, grain fed to pigs, bran fed to pigs, formula feed use, by-product feed use, labor inputs, grain production, and prices, as well as other demographic and marketing data. Detailed information about this survey can be found in Wailes et al. (1998).

The feed survey differentiated traditional household production and specialized households using the following criteria. A household production unit was considered a specialized household if:

1. 60 percent or more of the household labor is allocated to the specialized enterprise,

2. 60 percent or more of the household income is derived from the specialized enterprise,

3. 80 percent or more of the household sales are from the specialized enterprise, and

4. household per capita income is at least twice as high as the local area average per capita income.

This study focuses on traditional (backyard) household production, so observations for specialized households were not included in the data set used for estimation.

Since the data provide only a snapshot of Chinese pork production and the changes in elasticities over time cannot be estimated, we selected a double-log representation for equation (2). We constructed the household GCR by dividing the grain fed to pigs by the household’s annual pork production. The bran, formula feed, oilseed meal, and grain prices were included in our regression equation as input prices. We impose the homogeneity condition of factor demands by normalizing the bran, formula feed, and oilseed meal prices by the grain price to form the variables *BNGNPR, FFGNPR,* and *OMGNPR.*

The shift variables included in the regression are the number of days required to raise a hog to slaughter weight (*DAYS*), household per capita grain production (*HHGN*), the education level of the head of household (*EDUC*), and dummy variables for the region (*REGION*). The number of days required to raise a hog to slaughter weight was included in the regression to measure the impact of better management and feeding practices on feed demand. As households adopt more intensive management and feeding techniques, the length of time required for an animal to reach slaughter weight generally falls. Reducing the number of days on feed can decrease the total quantity of feed grain required for an animal to reach slaughter weight; however, higher daily feed-grain intake is often required to increase the rate of weight gain. Thus, decreasing the number of feeding days can have an ambiguous impact on the per unit grain conversion ratio. Per capita grain production was included in the regression to measure the impact of credit constraints and grain scarcity on unprocessed feed-grain consumption. Limited financial resources constrain household purchases of grain for feed from the market. Moreover, since much of the pork produced by traditional households is consumed in the household, purchases of grain to feed swine on credit are infrequent. Thus, the grain produced by the household is often the primary source for feed grain in traditional households. A dummy variable indicating the education level of the head of household was included to capture the effects of knowledge of superior management and feeding practices. Finally, regional dummy variables were added to gauge the impacts of differences in topography, geography, climate, and sociocultural characteristics on feed demand. The feed-grain supply and the availability of bulk and roughage feed differs across regions in China, and it can be expected that the GCR will also vary accordingly. The general regression equation is summarized as

(3)
$$\ln(GCR) = \alpha_0 + \alpha_1 \ln(BNGNPR) + \alpha_2 \ln(FFGNPR) + \alpha_3 \ln(OMGNPR) + \alpha_4 \ln(DAYS) + \alpha_5 (EDUC) + \alpha_6 \ln(HHGN) + \sum_{i=1}^{6} \beta_i REGION_i .$$

Estimation and Results

The data were grouped into three categories according to the household's annual pork production: (1) less than 200 kg, (2) between 200 kg and 500 kg, and (3) more than 500 kg. Demand equations were estimated separately for each group, as well as for the entire data set. This enables us to test whether households in all size categories share a common demand function for unprocessed feed grains. The estimated coefficients and t-statistics are reported in Table 3.

As in any study using cross-section data, heteroscedasticity is potentially a problem (Greene 1990). We expected that there would be greater variation for feed grain consumption among households with less than 200 kg of annual pork production than among households with larger pork output. The Breusch-Pagan test for heteroscedasticity was applied to the regression residuals, and the null hypothesis of homoscedastic errors was rejected at the 1 percent level for all three groups of producers. Consequently, the reported t-statistics for the estimated coefficients are based on standard errors that have been corrected for heteroscedasticity using White's procedure (1980).

Table 3. Regression estimates of grain conversion ratios for Chinese pork production

Variables	Annual Pork Production			
	<200 kg	200-500 kg	>500 kg	All
Intercept	0.255	-2.832	1.366	-1.143
	(0.46)	(-4.69)	(0.89)	(-2.79)
Per Capita Household Grain Production	0.035	0.250	0.417	0.112
	(0.84)	(5.21)	(2.40)	(3.61)
Oilseed Meal Price/Grain Price	0.022	0.606	0.747	0.219
	(0.34)	(7.50)	(3.43)	(4.14)
Bran Price/Grain Price	0.065	-0.155	0.116	-0.019
	(0.82)	(-1.67)	(0.55)	(-0.33)
Formula Feed Price/Grain Price	0.136	0.330	0.509	0.261
	(2.25)	(4.46)	(3.36)	(5.49)
Days to Reach Slaughter Weight	-0.078	0.202	-0.688	0.066
	(-0.86)	(2.19)	(-2.97)	(1.06)
Education	0.005	0.042	0.229	0.045
	(0.11)	(0.839)	(2.05)	(1.23)
Jilin Dummy	0.797	0.024	-0.840	0.484
	(5.51)	(0.13)	(-1.38)	(4.47)
Jiangsu Dummy	0.674	0.089	-0.942	0.422
	(5.65)	(0.61)	(-1.84)	(4.64)
Shandong Dummy	1.084	0.263	-0.634	0.808
	(8.75)	(1.61)	(-1.03)	(8.10)
Hunan Dummy	0.626	0.553	-0.395	0.547
	(5.80)	(3.58)	(-0.75)	(6.04)
Sichuan Dummy	0.463	0.319	0.001	0.386
	(4.23)	(2.27)	(0.00)	(4.58)
Shaanxi Dummy	0.778	0.440	-0.663	0.639
	(6.05)	(2.53)	(-1.31)	(6.11)
No. of Observations	802	626	130	1558
R^2	0.190	0.331	0.536	0.202

The results from the full sample estimation indicate that per capita household grain production and oilseed meal and formula feed prices are significant determinants of unprocessed feed-grain use. On average, the households in the sample used 30 percent of their total grain output to feed pigs. A 1 percent increase in household grain production leads to a 0.11 percent increase in the quantity of grain fed per kilogram of pork produced. As the price of grain increases relative to the prices of other feeds, household producers substitute oilseed meal and formula feeds for feed grain. The GCR is very inelastic with respect to substitute feed prices; the oilseed meal elasticity is 0.22 and the formula feed elasticity is 0.26. Although wheat and rice bran comprise 27 percent of total swine feed on average, the bran price, surprisingly, does not appear to be a significant determinant of unprocessed feed grain. The estimated coefficient for the bran price was insignificant and virtually zero in magnitude. This is likely because more than 80 percent of the bran used to feed swine was produced by the household, while more than 40 percent of the oilseed meal and all of the formula feed was purchased. If we assume the coefficient of the bran price term is zero, then the elasticity of demand with respect to the grain price is –0.479.

Most of the shift variables are important in determining the level of the GCR. The estimated coefficient for *DAYS* is positive but not significant at the 10 percent level. The positive sign indicates that, in general, changes in feeding and management practices that reduce the time on feed reduce the feed-grain intake per kilogram of pork produced. This is accomplished by substituting formula feeds and oilseed meal for less nutritious feeds, thus increasing the feed efficiency. The education level of the head of household is not significant at the 10 percent level, but the positive coefficient indicates that higher education levels tend to increase the GCR, suggesting that more educated farmers are more likely to employ feed-intensive management practices. Finally, the regional dummy variables are all positive and significant at the 1 percent level. The relative magnitudes of the coefficients indicate that GCRs are higher in Shandong, Shaanxi, and Hunan than in Jilin, Jiangsu, and Sichuan. Guangdong has the lowest average GCR. The average GCR for the entire sample was 2.298, while regional GCRs vary from 1.315 to 3.347.

Group I: Output Greater Than 200 Kilograms

When we focus on the group of producers with the lowest annual pork output, the formula feed price and regional influences have the greatest impact of the GCR. This finding is not surprising given the multipurpose nature of swine production and varied feed utilization for households with one or two pigs in the backyard. On average, swine producers in this category feed 1.53 kg of grain per day to their pigs, accounting for 33 percent of the total feed intake. Approximately 31 percent of the total feed used by small swine producers is wheat and rice bran, and an additional 31 percent comes from green feeds. Purchased formula feeds account for only 2.4 percent of total feed intake, and the elasticity with respect to the formula feed price is a mere 0.136.

Group II: Output Between 200 and 500 Kilograms

When producers increase their pork production above 200 kg but slaughter fewer than 5 hogs each year, the price of oilseed meal and per capita grain production become more significant in determining the GCR. The daily quantity of grain fed increases to 3 kg for producers in this category, accounting for 35 percent of total feed. Bran declines to 25 percent of the total ration, while oilseed meal increases to 1 percent and formula feeds to 5.7 percent. Households producing less than 200 kg of pork each year used only 18.5 percent of their grain output to feed pigs, but this percentage increases to 27 percent as output rises above 200 kg. The number of days to reach slaughter weight for households in this category is 218, 12 days less than for producers in the lowest output category and just three days below the sample average. Although grain intake per day increases as the time to slaughter decreases for households in this size category, the reduction in days on feed outweighs the feed increases. Consequently, shortening the time on feed by 2 days causes a 4 gram reduction in the GCR.

Group III: Output Greater Than 500 Kilograms

The results for households producing more than 500 kg pork indicate that these producers are more responsive to market forces. The elasticities with respect to the oilseed meal and formula feed prices increase to 0.75 and 0.51, implying an increase in the elasticity with respect to the grain price of –1.26. These results are consistent with the fact that for these households grain constitutes 39.5 percent of the total feed ration, for an average intake of 14.7 kg of unprocessed feed grain per day. Total feed-grain use exceeds annual household grain production by 14 percent, so a substantial portion of the grain fed to swine must be purchased. Oilseed meal increases to 1.3 percent of the total feed intake, and formula feed rises to 7.4 percent.

Unlike the results for smaller operations, decreasing the time on feed in larger operations increases the grain conversion ratio. The average length of time required for these households to raise a hog to slaughter weight is 183 days, more than a month shorter than the sample average. Although the daily grain intake is more than 4 times higher than that for households producing less than 500 kg of pork, the average GCR is 8 percent lower. Reducing the days on feed by one day in a larger operation causes the GCR to increase by 7 grams as grain is substituted for less nutritious bran and green feeds. The education level of the head of household has a positive impact on the quantity of grain fed to hogs by households in this category. More educated farmers use an average of 0.23 kg more grain per kilogram meat produced. Finally, as more grain is purchased from the market, the regional differences that affect grain production become less important in determining the GCR.

Tests for Structural Change

As traditional household pork producers in China increase their output beyond their own consumption needs, they depend increasingly on markets to provide their feed inputs. One outcome of estimating the grain conversion ratio separately for each production category is that there are notable differences in the price elasticities across groups. Moreover, the impact of days on feed varied from medium to large operations, as did the significance of the farmer's education level and regional effects. Testing for structural change as the production level increases will allow us to determine if the observed differences are statistically significant.

The Chow test can be used to test for structural change in OLS regressions (Chow 1960). However, the Chow test is based on the assumption that the disturbance variance is the same for all regressions tested. If the restricted model is heteroscedastic, the results of the classical regression no longer apply. When the Chow test is applied to data with heteroscedastic errors, it is possible to overestimate the significance level of the test statistic (Schmidt and Sickles 1997, Ohtani and Toyoda 1985). An alternative to the Chow test in large samples is the Wald test. Suppose that θ'_1 and θ'_2 are two normally distributed estimators of a parameter based on independent samples with variance matrices V_1 and V_2. Then under the null hypothesis of no structural change, the two estimates have the same expected value. The difference between the estimates, $\theta'_1 - \theta'_2$, has mean 0 and variance $V_1 + V_2$. Thus, the Wald statistic, $W = (\theta'_1 - \theta'_2)' (V_1 + V_2)^{-1} (\theta'_1 - \theta'_2)$, has a Chi-square distribution with K degrees of freedom. The Wald test was applied to the estimated coefficients and corrected covariance matrices from the regressions for the three size categories.

The null hypothesis of the test is that households in different groups share a common grain demand function. The critical value for the test is 26.22. The test statistic for a comparison between the smallest two production categories is 120.25, indicating that the null hypothesis can be rejected at the 1 percent level. The Wald statistic from the comparison of the medium and large operations is much smaller (67.22) but still implies that the null hypothesis is rejected at the 1 percent level. Given the results from the two previous comparisons, it is no surprise that a comparison of the smallest and largest production categories also soundly rejects the null hypothesis with a test statistic of 191.87. Consequently, these tests suggest that the changes in production and management practices that occur as the scale of production increases significantly alter the responsiveness of the household's feed-grain demand to price movements and differences in the regional environment.

Summary and Conclusion

This study provides empirical evidence of the determinants of feed-grain demand by traditional pork-producing households in rural China. In particular, we were interested in measuring the responsiveness of household feed demand to input prices. Estimation of a simple unit feed demand equation using household survey data revealed that feed prices are significant determinants of household demands for unprocessed feed grain, but those demands are inelastic in their response to changes in the oilseed meal, formula feed, and grain prices. The regression results also indicted that household grain production and differences in the environment across regions are important to producers' feed choices.

Disaggregating the data by production level, however, revealed that producers desiring only to meet their household pork consumption needs behave differently from those more oriented toward market sales. Households with annual pork production of less than 200 kg are not responsive to most feed prices, primarily because virtually all of their feed grain is provided by household production. Grain feed demand in these households is very inelastic with respect to purchased formula feeds. Moreover, less grain is fed on a daily basis, and a larger portion of the pig's diet is composed of by-products and green feeds. Thus the relative availability of feed resources across regions is very significant for feed-grain demand. Households producing more than 500 kg of pork each year exhibited more market-oriented production responses to changes in feed prices. The response to changes in oilseed meal and formula feed price changes is more than double that for the full sample regression, and the response to grain price changes is elastic. Moreover, regional differences play a much smaller role in determining feed demand, because a larger proportion of total feed is purchased from input markets. Finally, the length of time on feed has a significant negative impact on feed-grain demand. Consequently, as these producers continue to adopt more modern management practices that reduce the time for hogs to reach slaughter weight, the grain fed per unit of pork produced will increase.

The empirical results suggest that per unit feed demand in China decreases as household pork production rises from subsistence levels to more than 500 kg per year. Producers accomplish the reduction by substituting more formula feed and food by-products for less nutritious feeds. However, as output continues to rise above 500 kg, more feed grain is necessary to capture the production efficiencies embodied in modern techniques. Consequently, the average per unit feed-grain demand is likely to increase in China as the number of traditional households with low levels of pork production diminishes. Therefore, increasing domestic pork production to satisfy growing meat demand in China is likely to increase feed-grain demand in a nonlinear fashion.

ENDNOTES

1. The survey research conducted by UOA and RCRE was funded in part by the Center for Agricultural and Rural Development (CARD) at Iowa State University and by the Economic Research Service at the U.S. Department of Agriculture.

REFERENCES

Carter, Colin, and Funing Zhong. 1991. "China's Past and Future Role in Grain Trade." *Economic Development and Cultural Change* 39(4):791-814.

Chow, G. 1960. "Tests of Equality Between Sets of Coefficients in Two Linear Regressions." *Econometrica* 28: 591-605.

Fan, Shengen, Eric J. Wailes, and Gail L. Cramer. 1995. "Household Demand in Rural China: A two-stage LES-AIDS Model." *American Journal of Agricultural Economics* 77(1): 54-62.

Food and Agricultural Organization. 1995. *FAO Production Yearbook 1994.* Rome: FAO.

Gou, Tingshuang, Zhenhai Yang, and Wei Kang. 1996. "A Study on the Strategy of Feed Development in China." In *Research Progress in Animal Industry and Animal Products Processing,* compiled by the Department of Animal Husbandry and Health, Ministry of Agriculture, and Chinese Association of Agricultural Science Societies. Beijing: China Agricultural Scientech Press.

Greene, Willian H. 1990. *Econometric Analysis*. New York: Macmillan Publishing Company.

Halbrendt, C., F. Tuan, C. Gempesaw, and D. Dolketz. 1994. "Rural Chinese Food Consumption: the Case of Guangdong." *American Journal of Agricultural Economics* 76:794-99.

Han, Zhirong, and Yafan Feng. 1992. *New China's Agricultural Price: 40 Years* (in Chinese). Beijing: Hydraulic and Electric Engineering Publishing Company.

Hayes, Dermot J., and Roxanne Clemens. 1997."The Chinese Market for U.S. Pork Exports." CARD Briefing Paper (97-BP 14). Center for Agricultural and Rural Development, Iowa State University, Ames.

Lewis, P., and N. Andrews. 1989. "Household Demand in China." *Applied Economics* 21:793-807.

Ohtani, K., and T. Toyoda. 1985. "Small Sample Properties of Tests of Equality Between Sets of Coefficients in Two Linear Regressions Under Heteroscedasticity." *International Economic Review* 26: 37-44.

Qu, Weishuang. "A Comparison of Seven China Agriculture Models." Paper presented at the Millenium Institute's Strategy and Action Project for Chinese and Global Food Security Working Meeting, February 18-19, 1998. Washington, D.C.

Schmidt, P., and R. Sickles. 1977. "Some Further Evidence on the Use of the Chow Test Under Heteroscedasticity." *Econometrica* 45: 1293-1298.

Simpson, J.R., Xu Cheng, and Akira Miyazaki. 1994. *China's Livestock and Related Agriculture: Projections to 2025.* Wallingford, UK: CAB International.

Tong, Han, and Thomas I. Wahl. 1998. "China's Rural Household Demand for Fruit and Vegetables." *Journal of Agricultural and Applied Economics* 30(1):141-150.

Tuan, Francis C. 1987. "China's Livestock Sector." Economic Research Service, Foreign Agricultural Economic Report no. 226. Washington, D.C.: U.S. Department of Agriculture.

Wailes, Eric J., Cheng Fang, Xiaohui Zhang, Liqun Cao, Hansheng Cheng, Zhigang Wu, and Juanjun Guo. 1998. "China's Livestock Feed Use Relationships: Preliminary Results from a Survey in Seven Provinces." In *Food Markets in China: New Looks and Deeper Understandings*. Proceedings of the Western Coordinating Committee (WCC-101) annual conferences. January 12-13, Honolulu. Pulhman, Washington: IMPACT Center, Washington State University.

Wailes, Eric J., Cheng Fang, and Francis C. Tuan. 1998. "U.S.-China Agricultural Trade: Constraints and Potential." *Journal of Agricultural and Applied Economics* 30(1):113-126.

Wang, Q., F. Fuller, D. Hayes, and C. Halbrendt. 1998 "Chinese Consumer Demand for Animal Products and Implications for U.S. Pork and Poultry Exports." *Journal of Agricultural and Applied Economics* 30(1):127-140.

White, H. 1980. "A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity." *Econometrica* 48:817-838.

World Bank. 1993. *China: Animal Feed Sector Study.* Agricultural Operations Division, Report No. 10922-CHA.

Zhang, Xiaohui, and Lu Mai. 1997. "Study on China's Pig Raising Size and Feed Meat Conversion Ratio." *Chinese Journal of Rural Economy* 5:53-55.