Output Supply and Input Demand System of Commercial and Backyard Poultry Producers in Indonesia[1]

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Summary

Estimated Indonesian backyard and commercial broiler output supply and input demands from normalized quadratic function satisfy all theoretical properties (homogeneity, reciprocity, adding-up, symmetry, curvature). Elasticities have correct signs and are significant. Very inelastic supply explains strong border protection and casts doubt on long-term sustainability of import substitution policy.

Keywords: broiler trade, Indonesian poultry production, normalized quadratic profit function, production economics.

Output Supply and Input Demand System of Commercial and Backyard Poultry Producers in Indonesia Introduction

1. Introduction

Population growth, urbanization, and improvement in per capita real income have spurred the growth of meat consumption in Indonesia. Broiler consumption has gained an increasing share in the meat basket because of its lower price (the beef price is 2.26 times higher) and religious restrictions on other meats (e.g., pork). Table 1 shows that compared with pork and beef, only per capita broiler consumption shows an increasing trend since the 1997-98 macroeconomic crisis, reaching 3.12 kilograms (kg) per capita in 2003. Combined with border protection, such as the ban on imports of poultry parts and strict inspection requirements for "halal" meat certification, the growth in broiler demand has encouraged an expansion of domestic broiler production. Broiler production increased by 17.25 percent in 1996. In turn, this has driven growth in the imports of corn and soymeal for feed production. A small importer of corn and soymeal in the 1980s, Indonesia is now importing more than one million metric tons a year of each of the two major feed ingredients. Roughly 80 percent of its imported corn is used for production of feeds for poultry.

However, Indonesia's poultry sector suffered a serious blow following the country's financial crisis of 1997 (when the rupiah depreciated by 244 percent in 1998, inflation skyrocketed to 75 percent, and real per capita income dropped from $1,000 in 1996 to $205). Production in 1998 was less than half of the 605 thousand metric ton pre-crisis level in 1996. The drop is due to the poultry sector's strong ties to the exchange rate situation, with a large proportion of its operating costs based on dollar-denominated

imports such as feed and breeder stock. About 60 to 65 percent of the cost of production is accounted for by feed cost, with imported corn and soymeal representing the largest share. Recovery of the poultry sector was slow, reflecting lingering macroeconomic problems. Production exceeded the pre-crisis level only after six years, in 2002.

The broiler sector is highly concentrated. It is reported that only five big companies control the importation of grandparent stock, production, processing, and the distribution of broiler meat. Roughly 90 percent of production is either through contractual arrangements or direct partnership with large integrators.

Indonesia's rapid growth in domestic broiler production has been accomplished by maintaining a domestic price that is 55 percent higher than the world price before the crisis.[2] Despite its 70 to 50 percent bound rate under GATT, Indonesia's duty for broilers is not prohibitive at 5 percent. However, the real protection comes in the form of a ban on imports of poultry parts and strict inspection requirements for "halal" meat certification. With these restrictions in place, Indonesia has allowed only an insignificant amount of imports, representing a miniscule 0.56 percent of production. Whether Indonesia will continue to protect the domestic broiler sector and import feed grains and other inputs or whether it will directly import meat products is a relevant question to many stakeholders. This study examines the production behavior of both commercial and backyard broiler producers in Indonesia in order to evaluate the growth potential of the sector and the sustainability of its import-substitution policy regime. The research includes estimation of a theoretically consistent system of output supply of broilers and input demand for

[2] This has dropped significantly in recent period after the liberalization of the corn and soymeal markets and relatively higher world broiler price.

three major inputs: day-old chick stock, feed, and labor. The supply parameters are key in determining future growth potential of the sector as well as its feed requirements.

2. Model

The examination of the production behavior of commercial and backyard producers focuses on producers' output and input use decisions, specifically on their responsiveness to prices. Given an unrestricted profit function in equation (1),

$$\pi^* = \pi(p, w)\,, \tag{1}$$

where π is profit, p is output price, and w is a vector of input prices, the output supply (y) and input demand functions (x) are easily derived using Hotelling's lemma by taking the derivative of equation (1) with respect to output and input prices. That is,

$$y^* = \frac{\partial \pi(p, w)}{\partial p} \tag{2}$$

and

$$x_i^* = -\frac{\partial \pi(p, w)}{\partial w_i}\,. \tag{3}$$

The profit function in (1) has standard properties: it is continuous, non-decreasing in p, non-increasing in w, homogenous of degree one in p and w, and convex in p and w. Similarly, the output supply in (2) and input demand functions in (3) exhibit theoretical restrictions reflecting the properties of the profit functions. These properties are expressed in elasticity form as follows:

Homogeneity

$$\varepsilon_{y.p} + \sum_j \varepsilon_{y.w_j} = 0 \tag{4a}$$

$$\varepsilon_{x_i.p} + \sum_j \varepsilon_{x_i.w_j} = 0 \tag{4b}$$

Symmetry

$$\varepsilon_{x_i.w_j} R_i = \varepsilon_{x_j.w_i} R_j \tag{5}$$

Reciprocity

$$\varepsilon_{y.w_i} S = \varepsilon_{x_i.p} R_i \tag{6}$$

Adding-up

$$\varepsilon_{y.w_j} S + \sum_i \varepsilon_{x_i.w_j} R_i = 0 \tag{7a}$$

$$\varepsilon_{y.p} S + \sum_i \varepsilon_{x_i.p} R_i = 0 \tag{7b}$$

where S and R_i are shares of output and input values to profit.

The literature uses several flexible functional forms to give a second-order Taylor approximation to an arbitrary (true) functional form, including translog (by Christensen et al. 1973, and Diewert 1971), generalized Leontief (by Diewert 1971), symmetric generalized McFadden (by Diewert and Wales 1987), and normalized quadratic (by Lau 1974 and 1976) functions. However, Shumway (1983) suggested that the normalized quadratic function is attractive because it maintains linear homogeneity of the profit function and has several desirable properties. First, it is self-dual. Second, because both the normalized profit and input requirement functions are quadratic, their respective Hessians are matrices of constants so that the local convexity in prices implies global convexity (Lau 1978). And finally, using the envelope theorem, the first derivatives of this function provide output supply and input demand equations that are linear in

normalized prices of outputs and variable inputs and in the quantities of fixed inputs. In a later study, Shumway and Lim (1993) evaluated the sensitivity of U.S. output supply and input demand elasticities to the choice of three functional forms: translog, generalized Leontief, and normalized quadratic. They found considerable sensitivity to the choice of functional form, and the translog was generally the least preferred among the three forms. The relatively parsimonious and linear specification of a normalized quadratic function lends itself to easier estimation and has given this functional form wider empirical application. Several studies with multiple output and input systems that use both aggregate time-series data and cross-sectional farm-level data have employed a normalized quadratic profit function to estimate output supply and input demand elasticities. These include Shumway 1983; Shumway and Alexander 1988; Shumway, Saez, and Gottret 1988; Huffman and Evenson 1989; Dupont 1991; Villezca-Becerra and Shumway 1992; Kohli 1993; Hattink, Heerink, and Thijssen 1998; Ahammad and Islam 1999; Terry and Marsh 2000; and Hill et al. 2001. In this paper, a normalized quadratic function is used to estimate the output supply of commercial and backyard broiler production and input demand for Indonesia.

Equation (1) is specified as a normalized quadratic profit function with the output price used as a *numéraire.* That is,

$$\widehat{\pi} = \beta_0 + \sum_i \beta_i \frac{w_i}{p} + \frac{1}{2}\sum_i \sum_j \beta_{ij} \frac{w_i}{p}\frac{w_j}{p}. \tag{8}$$

The derived equations used for estimating input demand and output supply are given in (9) and (10):

$$x_i = -\left(\beta_i + \sum_i \beta_{ij} \frac{w_j}{p}\right) + \varepsilon_i \tag{9}$$

$$y = \beta_0 - \frac{1}{2}\sum_i \sum_j \beta_{ij} \frac{w_i}{p} \frac{w_j}{p} + \mu_i . \tag{10}$$

The error terms $\{\varepsilon,\mu\}$ are identically independently distributed. Homogeneity and adding-up are satisfied by construction in a normalized quadratic profit function. Symmetry is imposed as $\beta_{ij} = \beta_{ji}$. Convexity is simply checked after the estimation.

3. Empirical Results

The Bureau of Statistics in Indonesia (Badan Pusat Statistik, or BPS) regularly collects annual production and cost data from various sources, and conducts household production surveys. The last household survey was in 1996, immediately before the macroeconomic crisis. Another source of production data is that submitted by registered enterprises to the BPS for the purpose of development planning and evaluation. This data collection effort is mandated by law. Participating registered enterprises are normally larger-sized operations. We use the 1996 and 2000 registered enterprise data to allow comparison of production behavior over time before and after the crisis, and the 1996 household survey data to compare behavior of producers who have significant differences in their organization and scale of operation. The system of equations given in (9) and (10), with broilers as the single output and three inputs including day-old chicks, feeds, and labor, were estimated using SUR in SAS Version 8.2.

The quantity of output is reported in the survey and given in number of chickens (thousand birds). The stock input variable is calculated as the number of chickens from

buying (mostly day-old chicks) and other additions. The value of output and stock input for each year is derived the same way using the value of each category in rupiah. Broiler feed is the sum of starter and finisher broiler feed. The value of feed cost is in ruphia, and the quantity is in metric tons. Labor input has two parts. The first part includes the full-time workers and temporary workers with annual salary reported. The second part contains the expense for daily paid workers or workers by contract with their daily wage rate reported. A single daily wage is then computed for all type of workers. Implicit prices of both output and the three inputs are simply derived as the ratio of the value to their respective quantities.

Descriptive Statistics

Table 2 gives descriptive statistics of the data used in estimation. The average production level per farm for registered establishment at 35.84 thousand birds is eight times larger than the production level of household producers at 4.58 thousand birds. Also, the average production level for registered establishments increased by 24 percent between 1996 and 2000. In terms of input prices, household and registered establishment producers face the same feed price, but the labor price paid by households is only one-fifth of that paid by registered establishments, likely reflecting more own-labor used by household producers. Household producers report a higher average price for broilers, a result that may be due to a difference in market outlets. That is, household producers may have the option to bring their birds directly to the retail market (i.e., wet markets) while the larger producers may be reporting farmgate prices.

Table 3 gives the distribution of poultry farms by size. Household production ranges from only 400 to 7,940 birds per year and is not reported in the table. There is a clear

increase in the size of operation between 1996 and 2000 for registered establishments. The frequency of the lower-sized categories declined, while the frequency of the top two size categories increased, with a relatively large increase, at 5.7 percentage points, for producers above 100 thousand birds per year.

Table 4 shows productivity measures for the producers. In addition, the mortality rate is higher in household production at 13.8 percent, compared with 3.4 percent in registered establishments. The difference between the two production systems in the feed use per bird is not very large, with household producers using 0.107 kg more feed per bird in 1996 than for the registered enterprises. Between 1996 and 2000, registered establishments show a significant decline in the feed use per bird, from 2.87 kg to 2.37 kg. Registered establishments show higher efficiency in converting feed use into meat produced, with only 2.39 kg of feed to produce a kilo of meat compared to 2.48 kg for household producers. Over time, registered establishments have improved feed efficiency, cutting the feed conversion from 2.39 kg in 1996 to 1.97 kg in 2000. The survey does not provide information on weight per bird, however, other sources (the Foreign Agriculture Service, U.S. Department of Agriculture) estimate weight per bird increasing from 0.80 kg per bird in 1998 to 1.0 kg in 1999. This is much lighter than the average liveweight at slaughter under federal inspection in the United States, which is reported at 2.19 kg per bird.

Broiler Supply

Parameter estimates from the production system (input demand and output supply) are given in Table 5. Homogeneity, reciprocity, and adding-up were imposed by construction; symmetry was imposed in estimation; and curvature was checked and found

to be satisfied with a positive semidefinite parameter matrix. With one output and three inputs in the model, only 10 parameters are freely estimated, and the rest of the parameters are derived from theoretical restrictions. . Tables 6 to 8 gives the elasticity estimates (with their corresponding standard error) of the output supply and three input demand equations for 1996 and 2000 registered establishments and 1996 household producers. The signs of the own-price elasticities for the broiler supply and input demand are all theoretically consistent, with a positive supply and negative demand elasticity. The day old chick and feed input demand equations have the expected positive elasticity with respect to the output price, and the broiler supply equation has the expected negative elasticity with respect these input prices.

The magnitude of the supply elasticity seems to be smaller than expected (0.217 for the broiler supply elasticity in the 2000 dataset). There are two possible data-related explanations for the small supply elasticity. First, since the elasticity is estimated from survey data, only the short-run response is captured. Second, and more important, the total supply elasticity is the sum of the elasticity of the number of birds produced and the elasticity of the weight per bird. Because of data limitations, only the former can be estimated. In the United States, the elasticity of the number of birds represents a share of 76 percent of the total supply elasticity. Applying the same share, the likely total supply elasticity in Indonesia would be 0.285.

Estimates based on the 1996 and 2000 registered establishment surveys allow comparison between the two periods. The elasticity estimates for registered establishments for 1996 and 2000 (Tables 6 and 7) show an increase in the magnitude of the supply elasticities by 1.4 times (from 0.150 to 0.217) and by 1.7 times in the feed

demand elasticity (from -0.211 to -0.359). It should be noted that the model specifications between the two periods are different because the stock variable was not collected in the 1996 survey. Also, the elasticity estimates are significant in 2000 but not in 1996.

The 1996 household survey allowed estimation of supply parameters for household producers, as shown in Table 8. The 1996 feed demand elasticities estimated for household producers are similar to those estimated registered establishments (-0.296 compared to -0.211). However, as shown in Tables 7 and 8, household producers are more responsive to the broiler price and have a supply elasticity nearly twice that of registered establishments (0.361 compared to 0.150). One might expect the supply elasticity of larger, registered establishments to be larger due to greater market orientation of the registered establishments.

4. Summary and Conclusion

With competing meats either too expensive, as in the case of beef, or banned by religious persuasion, as in the case of pork, broiler meat has gained an increasing share in the consumption basket of Indonesian consumers. Per capita broiler consumption increased by 3.02 percent annually over the last eight years despite a deep macroeconomic crisis in the late 1990s. Combined with border protection, such as the ban on imports of poultry parts and strict inspection requirements for "halal" meat certification, the growth in broiler demand has encouraged an expansion of domestic broiler production. Production increased by 17.25 percent in 1996, though the sector suffered a serious blow during the 1997 financial crisis because a large proportion of its operating cost was based on dollar-denominated imports such as feed and breeder stock. By 1998, production had collapsed by 53 percent compared to the 1996 level. The sector has since recovered to pre-crisis levels.

Indonesia's rapid growth in domestic broiler production has been accomplished by maintaining a domestic price that was 55 percent higher than the world price before the crisis.

With its current policies of banning imports of poultry parts and requiring strict inspection for "halal meat," Indonesia has only allowed a very small amount of broiler imports, representing only 0.56 percent of production. This has encouraged growth in domestic broiler production and driven growth in the imports of corn and soymeal for feed production. A small importer of corn and soymeal in the 1980s, Indonesia is now importing above one million metric tons a year for each of the two major feed ingredients.

Indonesia faces growing domestic demand for poultry, yet currently follows policies that substitute feed grain for poultry imports to encourage domestic poultry production. By using recent data for registered establishments and household producers, the study estimates a theoretically consistent output supply of broiler and input demand for three major inputs: day-old chick stock, feed, and labor in order to better understand the supply situation. Production and cost data were collected by BPS from registered establishments (more commercial in scale) for 1996 and 2000, and data from a household survey for 1996. These datasets allow a comparison of elasticity estimates of similarly organized producers across time (between pre-crisis and post-crisis periods for commercial producers) and differentially organized producers (household and commercial producers) for the same time period.

For the most recent dataset, own-price elasticities in both the output broiler supply and input feed demand equations are significant, with t-ratios greater than 2. The signs of

the elasticity for the broiler supply and all three input demand are theoretically consistent, with a positive supply and negative demand elasticity. Stock and feed input demand equations have positive elasticities with respect to broiler (output) price. Also, the broiler supply equation has a negative elasticity with respect to these input prices.

The magnitude of the supply elasticity is smaller than expected. In addition to other measurement factors, the seeming lack of responsiveness of the broiler sector may reflect policy interventions that have limited the movement of both product and factor prices. Also, the policy regime governing the sector may contribute to non-price considerations having relatively more influence in the economic decisions of broiler producers. The inelastic supply in Indonesia implies that any income-driven expansion in the quantity demanded would be quickly constrained by rising prices. Consequently, supply from imports would become attractive, which would dampen the incentive for growth in the domestic sector, if imports were allowed entry into the country.

Between the pre-crisis and post-crisis periods, the elasticity of the broiler supply equation with respect to the broiler price increased only by 1.4 times, while the elasticity of feed demand with respect to feed price increased 1.7 times in 2000 compared with 1996.

Among other factors, this differential may be due to the change in the policy regime with respect to the importation and distribution of food and feed grains. Prior to the crisis, Bulog (Badan Urusan Logistic Nasional), the government-run logistics agency for basic foodstuffs, was the only importer and local distributor of food and feed grains. Its trading activity was directly tied to attaining the low and stable price objectives of the Indonesian government. In the liberalization reform package that Indonesia accepted as part of the

International Monetary Fund (IMF) loan conditionality, Bulog's role in the importation and distribution of food and feed grains was substantially reduced in the post-crisis period.

Between household and registered establishments in 1996, the elasticity of the feed demand equation with respect to feed price is in the same range, while the elasticity of broiler supply with respect to broiler price is two times larger for household producers compared with that of registered establishments. However, the real incentives faced by the two types of producers may not be fully captured by the prices used in estimation because of their differential access to government programs and differing ability to expand operations due to differential fixed capital requirements and contractual obligations. Also, it should be noted that the elasticity compared is on the number of birds produced. Since commercial operations are more intensive in their feeding practices and capital use, it is likely that their responsiveness to changing economic incentives can come relatively more through changes in slaughter weight than in number of birds when compared to household producers.

Table 1. Indonesian broiler supply and use and per capita meat consumption

	Broiler Supply and Use				Per Capita Meat Use		
Year	Production	Imports	Exports	Use	Broiler	Pork	Beef
	Thousand Metric Tons				Kilograms per person		
1995	516	0	0	516	2.51	2.78	1.52
1996	605	0	0	605	2.89	2.87	1.66
1997	515	0	0	515	2.42	2.97	1.66
1998	285	0	3	282	1.30	2.87	1.58
1999	355	4	3	356	1.62	2.50	1.41
2000	458	14	1	471	2.10	1.84	1.57
2001	522	1	2	521	2.29	2.03	1.49
2002	632	0	3	629	2.72	2.04	1.47
2003	735	0	3	732	3.12	2.01	1.45

Table 2. Descriptive statistics

		Mean			Standard Error		
		Small	Commercial		Small	Commercial	
Items	Units	1996	1996	2000	1996	1996	2000
Production	000 Birds	4.58	35.84	44.30	2.06	18.42	26.61
Stock	000 Chicks	5.22		45.81	2.22		28.98
Feed	Metric tons	13.63	102.85	104.79	17.15	61.14	72.91
Labor	Day-person	490.61	1196.46	1604.77	236.48	1258.46	1286.42
Price							
Chicken	Rupiah/bird	5154.02	3771.86	9643.07	2323.51	728.30	1780.49
Stock	Rupiah/bird	723.31		2446.75	148.72		559.57
Feed	Rupiah/kg	781.68	781.66	2076.26	130.62	93.30	308.42
Labor	Rupiah/day	1019.00	4498.63	8093.37	767.56	2068.81	4482.61

Table 3. Distribution of poultry farms by size of operation of registered establishments

	Frequency		Cumulative Frequency	
Production (000 birds)	1996	2000	1996	2000
$Q < 25$	0.258	0.261	0.258	0.261
$25 \leq Q < 50$	0.538	0.451	0.796	0.712
$50 \leq Q < 75$	0.161	0.149	0.957	0.861
$75 \leq Q < 100$	0.043	0.082	1.000	0.943
$Q > 100$	0.000	0.057	1.000	1.000

Table 4. Productivity measures

		Small	Commercial	
Measures	Units	1996	1996	2000
Stock-production ratio*	Ratio	1.138		1.034
Feed per bird	Kilogram	2.976	2.869	2.366
Labor per bird	Day-person	0.107	0.033	0.036
Feed conversion	Feed-Meat	2.480	2.391	1.971

* mortality rate is this ratio less one multiplied by 100.

Table 5. Parameter estimates from 2000 data

Equation-Variables	Coefficient	t-Ratio
Intercept		
Broiler supply	49.29	18.26
Day-old chick demand	-49.45	-8.38
Feed demand	-146.32	-9.72
Labor demand	-1.04	-2.46
Slope own-price		
Day-old chick price	7.16	0.76
Feed price	170.37	3.52
Labor price	0.08	0.55
Slope cross-price		
Day-old chick and feed	16.42	0.91
Day-old chick and labor	-2.12	-2.74
Feed and labor	-0.36	-0.24

Table 6. Elasticity estimates, 2000 registered establishment survey

	Price			
Function	Stock	Feed	Labor	Broiler
Broiler supply				
Elasticity	-0.021	-0.207	0.011	**0.217**
Std error	0.034	0.073	0.008	**0.107**
Stock demand				
Elasticity	**-0.040**	-0.079	0.040	0.080
Std error	**0.053**	0.087	0.015	0.126
Feed demand				
Elasticity	-0.041	**-0.359**	0.003	0.396
Std error	0.044	**0.102**	0.012	0.141
Labor demand				
Elasticity	0.341	0.049	**-0.041**	-0.350
Std error	0.125	0.207	**0.074**	0.259

Table 7. Elasticity estimates, 1996 registered establishment survey

	Price		
Function	Feed	Labor	Broiler
Broiler supply			
Elasticity	-0.130	-0.024	**0.154**
Std error	0.159	0.020	**0.166**
Feed demand			
Elasticity	**-0.211**	0.000	0.211
Std error	**0.252**	0.032	0.259
Labor demand			
Elasticity	-0.007	**-0.576**	0.583
Std error	0.484	**0.225**	0.485

Table 8. Elasticity estimates, 1996 household survey

	Price			
Function	Stock	Feed	Labor	Broiler
Broiler supply				
Elasticity	-0.093	-0.233	-0.035	**0.361**
Std error	0.039	0.144	0.015	**0.183**
Stock demand				
Elasticity	**-0.104**	-0.370	-0.038	0.512
Std error	**0.093**	0.171	0.042	0.218
Feed demand				
Elasticity	-0.129	**-0.296**	-0.026	0.450
Std error	0.060	**0.223**	0.022	0.278
Labor demand				
Elasticity	-0.299	-0.582	**-0.666**	1.547
Std error	0.329	0.492	**0.186**	0.647

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