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BEEF SUPPLY PRICE RESPONSE ESTIMATION AND IMPLICATIONS FOR POLICY ANALYSIS: THE ZIMBABWE CASE

by

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Introduction

1. In recent years, the actual and potential capacities of national agencies to undertake quantitative analyses of the impacts of various economic options have substantially increased. Various factors have contributed to this increased capacity. Among the important ones are:

   (1) The increase in the pool of economists who are oriented towards quantitative analysis.

   (2) The increasing ease of accessibility to the diverse mathematical economics literature.

   (3) The availability of users-friendly softwares in micro-computers.

2. Due to the pivotal role of price policy instruments in redirecting resource allocation and distribution; in providing benefits to particular sectors of the economy; and in generating exportable surplus, a premium is continually being attached by policy-makers to quantified estimates of the impacts of price changes. For example, governments are interested in the impact of changes in the price of beef on animal offtake levels because an excessive cattle herd size will exert pressure on communal grazing areas. Past studies in Africa provide a mixed result about the reaction of subsistence cattle producers to beef price adjustments. Quantitative estimates by Doran, Low, and Kemp (1979) and Rodriguez (1985) showed cattle herds in communal areas in Swaziland and Zimbabwe respectively will increase further as a result of beef price increases. One reason for the rise in herd inventories is that the increase in the price of beef results in a higher-cash value per animal unit. Hence, the subsistence-oriented livestock producers will sell less animals to meet their minimum money transaction demand. Khalifa and Simpson (1972) indicated a decline in animal inventories in Sudan as a result of increases in the price of beef. This can be attributed to the income effects of the larger cash generated in selling more higher priced animals. As the nomadic producer increases his cash income, his other demand for money (e.g, speculative motive in the form of gold ornament purchases) comes into play.

3. The objectives of this paper are:

   (1) To illustrate the role of supply price elasticities in policy making and analysis.

(2) To document our experience with respect to the sensitiveness (in terms of signs and absolute magnitudes) of beef supply price elasticities estimated for commercial farms in Zimbabwe and the corresponding policy implications.

Zimbabwe was selected as the case study because of the substantial role of price policy in shaping its livestock market structure.

The concept and nature of supply price elasticities

4. Supply price elasticities are derived from a rule that defines the relationship between a set of prices and output. In supply relationships, it is normally accepted that producers who try to maximize profits will increase (decrease) the supply of a commodity in response to an increase (decrease) in the price of that commodity subject to a given technology. The technology available to the producers determines the physical response of output to the use of a set of inputs — this is what economists refer to as a production function. Producers use changes in both output and input prices to determine the expected profitability of a particular production activity. Supply price elasticities refer to the percentage change in output arising from a percentage change in prices and are obtained from supply functions.

5. Given the above, a basic problem which farmers face when they decide about output responses to price changes is that they have to base their decision on future prices. This partly results from the lagged response of agricultural production to changes in prices. This is particularly important in livestock production, in most cases, due to the relatively long period that it takes for actual output to be realised. This is further complicated by the fact that physical production responses in future depends on past decisions affecting such things as the herd/flock dynamics (e.g, herd productivity structure, composition, offtake rates etc.) Producers' expectations are also influenced by a number of other external and internal factors among which the following are important:

(i) type of market, climatic and technological information confronting farmers;

(ii) government policies (e.g, input price subsidies);

(iii) farmers' own attitude toward risk-bearing;

(iv) farmers' own ability to process decision relevant information.

6. The process of estimating supply price elasticities for livestock products can be particularly complex. Consider for example the components of percentage change in the number of cattle slaughtered arising from a percentage change in the world beef price. Such a price-induced change can be decomposed into the following elements:

   (i) Percentage change in the number of cattle slaughtered due to the percentage change in the type of cattle (e.g, calves, heifers, oxen, bulls) killed.

   (ii) Percentage change in the type of cattle killed due to the percentage change in the quantity of inputs.

   (iii) Percentage change in the quantity of inputs due to the percentage change in the quality (e.g, crude protein content) levels of inputs.

   (iv) Percentage change in the quality levels of inputs due to the percentage change in the cattle capitalization rate (equated to the opportunity cost of a financial asset such as cash).

   (v) Percentage change in the cattle capitalization rate due to the percentage change in the domestic beef price.

   (vi) Percentage change in the domestic beef price due to the percentage change in the exchange rate.

   (vii) Percentage change in the exchange rate due to the percentage change in the world beef price.

7. Each of the previously mentioned components involve the dynamic response of the farmer to changes in prices and technological variables. Since the components are multiplicably related, some of the items highlight the impact of government interventions on the price adjustment process. For example if the government wishes to insulate the domestic beef market from the international market changes, strict foreign exchange policies (e.g, fixed exchange rate) can be pursued in a manner which will reduce the magnitudes of items (vi) and (vii) to zero. As a result, the response of domestic cattle slaughters to changes in the world price of beef will be nil.

8. Estimates of the expected behaviour of farmers in adjusting output to price changes distinguish between short- and long-run elasticities. The long-run is distinguished from the short-run in terms of the ability of a producer to

vary all his inputs in response to changes in prices. Since this ability varies according to the biological cycles and the technological process involved for different agricultural commodities it is not always possible to determine what constitutes the short- against the long-run in terms of precise time periods.

9. The expectation behaviour of farmers will vary depending on the weights they attach to a set of historical prices. This will be discussed in the context of empirical estimates for Zimbabwe. Farmers' expectation behaviour also varies with respect to their efficiency as processors of market information. In the extreme case, it is assumed that farmers may not learn from their past experience and respond to price changes in a way that sets in a process of wide fluctuations in price and output in the long-term -- economists refer to this as the cobweb theorem. In other situations, farmers are assumed to appropriately use and absorb market signals to adjust output to price changes expected (subjectively) to take place -- economists refer to this as the rational expectation model. Notwithstanding the above, most empirical supply elasticity studies for agricultural commodities assume that farmers will respond positively to price increases -- i.e a price increase will induce farmers to increase output.

10. Cattle slaughter relationships, however, present a different situation in the short-run -- i.e. an increase in the price of beef will reduce the number of cattle slaughtered. This implies that the marketable output of beef will be lower in comparison to a situation where prices did not increase -- i.e the short-run price elasticity of beef supply estimated from a given slaughter function will be negative. Disregarding the on-farm consumption effect, this situation could arise from two possible reasons. First, when beef prices increase, commercial producers will decide to build up their herd inventory (by retaining the most productive animals which will increase the herd size in anticipation of still higher prices in the future. They will increase their herd size up to the point where the marginal cost of an additional input is equal to the marginal return of an additional livestock output. Secondly, subsistence - oriented farmers will sell less (now higher-priced) animals to meet a target cash demand.

11. In a commercial production setting, witholding animals from the slaughter market due to increased prices will induce beef prices to increase even more because, other things being equal, of the decrease in beef supply. When those animals which were held back reach the "appropriate" slaughter age and/or

weight, producers will have to sell these animals. This would mean that increased slaughter levels will depress beef prices. Lower prices will further induce producers to sell as much as possible in anticipation of even lower prices in the future -- the other side of the coin explaining the negative supply response in cattle slaughter relationships.

12. The above provides an oversimplified picture of what is usually referred to as the cattle cycle in commercial beef production. Part of the reason of why beef supply responses are said to be negative in the short-run and positive in the long-run is explained by the cattle cycle phenomena. The positive long-run response of producers is explained by the increased supply of slaughter cattle forthcoming from those retained, following a lag of a number of years. The length of this lag depends on biological as well as technological factors indicated earlier (para 8). For example, Simpson (1979) indicates that this lag could last between 3 to 5 years in the U.S beef industry.

13. U.S. data on prices, output and technological inputs are clearly adequate (both in terms of the period they cover and their quality) to provide a good basis for defining (and even possibly predicting) how long the long-run is or can be. Data for other countries, particularly in Africa, are far from adequate. As a consequence, in such cases, while economic theory can provide us with some guidance on whether the price elasticity of supply in slaughter relationships is either negative or positive, empirical models do not answer the following questions clearly:

    (i) How long will the beef price elasticity remain negative?

    (ii) When does such elasticity become positive?

14. These questions address important policy issues related to domestic production, consumption and exports. The sign switch is important in that it will allow policy-makers to determine the possible cycles in the availability of beef to domestic consumers and when beef export commitments can be met. Some of the issues related to this aspect will be discussed in the context of the Zimbabwe pricing policy experience which is briefly described in the following section.

Beef pricing policy in Zimbabwe

15. The objective of the government pricing policy in Zimbabwe is to attain self-sufficiency in beef products and to generate a stable flow of foreign exchange earnings from the beef sector (see Rodriguez, 1985).

16. The agency responsible for implementing the beef price policies is the Cold Storage Commission (CSC). Formally established in 1937, its original mandate was heavily biased towards the synchronization of domestic beef output trends with foreign demand to stabilize export earnings.

17. Cattle are sold to the CSC by the commercial and communal sectors. Commercial producers use modern farm technologies while communal farmers employ less sophisticated techniques and a substantial portion of family labor. Communal farmers also consume a large proportion of their produce on the farm. Both the commercial and communal sectors showed an annual growth rate of 5% for the period 1965-77 in their respective herd inventories but an annual decline of 4% to 7% respectively applicable to the communal and commercial farms occured during the period 1977-81 due to drought and the deteriorating security situation. In 1984, the beef herd inventory was estimated to be 5,052,650 heads (Central Statistical Office (CSO)) of which 42% was owned by commercial farmers and the rest by communal farmers. Excluding slaughter for subsistence consumption, the CSC accounts on average for about 86% of the national slaughter of mature cattle.

18. The CSC implements two types of purchasing policies. For animals directly sold at CSC pens, a carcass grading scheme is used to determine the producer pay-out price. The Beef Classification System relies on three carcass characteristics:

    (i) Age (determined on the basis of the dental structure for young cattle and spinal ossification of more mature cattle);

    (ii) Flesh cover (determined in terms of the relationship between carcass length and mass);

    (iii) Fat cover (determined subjectively).

19. The implicit rationale behind the carcass grade pricing system is to discourage the slaughter of breeding animals crucial in preserving the cattle herd

reproduction cycle. In the case of communal areas wherein auctions take place at sites designated by the CSC, purchases are made on a liveweight basis.

20. For the commercial beef sector, producer prices are set by the government on the basis of total production costs (fixed and variable) incurred within alternative beef production systems. The cost data are provided partly by the Commercial Farmers' Union (CFU) and partly by the Ministry of Agriculture. Both sources derive their cost of production estimates from case studies of farming units located at the different ecological zones of Zimbabwe.

21. The CSC usually incurs substantial trade deficits (financed by Government subsidies) because it sells beef at wholesale prices below the domestic producer price. Jansen (1982) indicated that the deficits ranged from ZW$ 6.338 million to ZW$ 25.730 million for the period 1976/77 to 1981/82.

22. The ratio of domestic producer and retail beef prices to the equivalent border price (estimated at the official exchange rate) was examined to determine the beef subsidy (tax) bias. If the domestic producer to the border price ratio is greater than one, this means that a subsidy is implicitly being given to domestic beef producers, while a retail to border price ratio greater than one would mean that consumers are being implicitly taxed. Simple calculations based on actual data indicated that beef consumers are being taxed while producers are being subsidized. For example, during the period 1976-81, the retail to border price ratio was 1.16 while the domestic producer to border price ratio ranged from 1.22 to 1.64 for the period 1975-82 (Rodriguez, 1985). The incentive bias towards beef producers created by the CSC operations seems to be a familiar pattern in the context of South Africa. Anderson and Tyers (1986) noted a rising nominal protection trend granted to South African beef farmers and a declining subsidy trend to domestic consumers for the period 1961-83.

Beef supply response in Zimbabwe: Some empirical estimates and their implications.

23. In Zimbabwe, the cost of production approach is used to set the absolute price levels for beef. However, this approach cannot capture the various dynamic adjustments in input levels, number of cattle and technological

variables resulting from a given change in the price of beef. As a result of such deficiency, we examine the feasibility of using price elasticity parameters as an alternative quantitative basis for estimating the appropriate producer price (appropriate in terms of government policy objectives).

24. As mentioned earlier beef pricing policy objectives in Zimbabwe are aimed at attaining self-sufficiency in beef products and at generating a stable flow of foreign exchange earnings from beef exports. When the price of beef rises in the world market, the government would ideally want to see domestic producers exporting the corresponding amounts of beef. This could even be at the expense of domestic consumers, if government attaches a higher premium to the foreign exchange earning objective. In the light of the earlier discussion on the short-run responses of commercial producers to increased beef prices, the quantity of exports is unlikely to increase and may even decrease. Furthermore, since in the event domestic producers will decide to increase their herds in anticipation of further price increases, the domestic supply of beef to consumers can decrease abnormally. As a consequence retail prices will be pushed up.

25. In the case of Zimbabwe consumers, it has been estimated that a drop in the availability of beef per capita of say 5% can result in an upward pressure on retail prices of as much as 10% (Rodriguez, 1985). Adjustments in the CSC prices take a longer process than those in the free market because of the administrative steps involved (including the bargaining process among those with interest in the sector -- e.g. farmers, butchers) in determining the new price levels by government. There is thus a possibility of the development of a black market for beef as a result of the negative supply response by producers in the short-run.

26. Comparing the short-run response of Zimbabwe's commercial cattle sector to beef price changes with other countries indicates a wide diversity. For a 10% rise in beef prices, producers in Brazil will cut slaughter levels by 1.1 to 5.6%; Argentina by 6.7 to 9.6%; and Colombia by .58 to 12%. Even providing allowances for technological differences among countries, the dispersion of the absolute elasticity estimates is wide.

27. Beef supply responses to price increases in Zimbabwe have been estimated using different models and independent variables. The first of these, with undeflated beef prices and time trend as independent variables, estimates the beef price expectation behaviour of commercial beef producers through

a polynomial weighting function of price (almon model). The result shows that the short-run price elasticity of beef ranged from -0.49 to -0.61 which in other words means that if CSC increases the producer price by 10%, the number of cattle supplied for slaughter will decrease by 5 to 6%.

28. A second (almon) model used average CSC cattle prices deflated by a cost of living index to discount the producer price for the rate of inflation. These prices were further lagged by three to four periods to represent the set of price information known to the producer when he makes beef production decisions. Simply illustrated, this means that a commercial producer will take into consideration the 1986, 1985, 1984 and 1983 cattle prices in deciding on the number of animals he will deliver to CSC for slaughter in 1986. The estimated elasticities and the resulting output adjustments are shown under the first two main column headings of Table 1.

29. The third model is based on the assumption that beef cattle producers attach geometrically declining weights to beef prices of differing "age" — i.e. higher values to newer sets of price information (e.g 1986 prices) versus older sets.

30. On this basis, beef price elasticites were estimated using Zimbabwe commercial farm slaughter functions. Table 1 below presents these estimates per time period and the corresponding percentage adjustments in the number of cattle slaughtered for a 10% rise in the (deflated) price of beef.

Table 1. Estimated beef price elasticities classified by model structure

Period	Almon Model (Three-period price lags)		Almon Model (Four-period price lags)		Geometric Model	
	Elasticities	Output Adjustment %	Elasticities	Output Adjustment %	Elasticities	Output Adjustment %
Present	1.21	12.1	.15	1.5	-.44	-4.4
Previous period	-.95	-9.5	.24	2.4	-.28	-2.8
Previous 2 period	-.48	-4.8	.42	4.2	-.17	-1.7
Previous 3 period	2.60	26.0	.70	7.0	-.11	-1.1
Previous 4 period	N.A.	N.A.	1.08	10.8	-.07	-.7
"Long-run"	2.38	23.8	2.59	25.9	-1.19	-11.9

Notes: (1) N.A. = Not applicable.
(2) All elasticities estimated at the means for the almon models.

31. The elasticity estimates in Table 1 represent the potential diversity in the nature of economic reports reaching the key policy-makers resulting from the use of different estimation models. For example, if the cabinet decided to raise real beef producer prices by 10%, an economist using a three-period price lag almon model will forecast an incremental increase in slaughter levels in the current period 8 times higher than the one using a four-period lagged price. Use of the geometric model will result in a prediction of a current 4.4% incremental decline in the number of cattle slaughtered. The four-period price lag model also indicates a continuous increase in slaughter levels for a given beef price increase in all periods while the geometric model shows the reverse pattern. The almon estimate indicates a 10.8% increase in the number of animals slaughtered in response to the fourth period lagged price while the geometric model forecasts a 0.7% decline.

32. Long-run supply response estimates given in the last row of Table 1 indicate marginal increases in slaughter levels of about 24 - 26% under the almon models, but marginal decreases of about 12% in the geometric model. Conversely, these imply a decrease or an increase of the same magnitude in the number of cattle retained under the almon and geometric models respectively. Hence, if degradation pressures arising from increasing animal populations in relation to beef pricing policies are being scrutinized, then the estimates under the geometric model can lead to economic measures designed to control animal numbers which graze communal areas.

33. The policy signals deriving from these estimates using the different empirical models can be confusing. There are several technical reasons for the unstable signs and absolute magnitudes of the beef price response parameter for the two models. There is no simple way to explain in this paper the technical (statistical) complexities involved. However, much of the problem usually arises from the non-inclusion of some potentially powerful explanatory variables, due to data limitations, in the process of estimating such supply relationships -- e.g. livestock research.

34. Such sources of technical problems cannot be totally eliminated from statistical data sets and are particularly acute in African countries. In the light of this, the question becomes: to what extent can policy-makers place their faith in quantitative estimates? Most decision-makers burdened with myriad

responsibilities may not even afford the time to judge the strength of the basis of their decision. For the die-hard quantitative supporters (a likely rare specie of policy-makers?) it is quite crucial to validate the models used in computing the critical economic parameters. Validation involves not only subjecting the models to rigorous statistical tests but also requires the subjective evaluation of industry specialists.

Conclusion

35. This paper highlighted the role of supply price elasticities in the price-policy formulation process. The policy implications resulting from the absolute magnitudes and signs of such parameters were illustrated through the use of estimates obtained directly from the Zimbabwe livestock commercial data and from comparative studies for some countries. The elasticity estimates indicate a wide dispersion across countries and across the expectation models fitted to the Zimbabwe data. As a result, depending on the researchers' elasticity estimates, the resulting policy recommendations will not be unique. For example, the usage of the elasticity estimates provided by the geometric model will indicate a continuous herd inventory build up corresponding to a sustained beef price increase while those obtained from the almon models indicate a decline in the cattle herd in the long-run.

36. The large diversity in the signs and absolute mangitudes of the elasticity estimates need not be a reflection of the inherent weakness of the quantitative models. It rather reflects the limited experience of the policy analysts in adapting the relevant quantitative research tool to a particular policy scenario. As a result of such limitation, the process of model validation through formal statistical tests and informal critiques of persons with substantial field experience assumes an important role. It is recognized that in the actual policy planning system, the demand for a quick turn-around time in model results exerts a substantial pressure to curtail the validation phase. The long-term minimization of the pressures from immediate research policy feedbacks will rely largely on how much risk policy-makers are willing to take with inaccurate quantitiative results.

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