Transportation Costs in Econometric Models of State Agricultural Sectors: The Case of Beef in Hawaii

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Econometric models designed to show how national policies affect state agricultural sectors often use national prices as proxies for state prices. Consequently, they ignore the influence of freight rates on state production. An application to the Hawaii beef industry demonstrates that both freight rates and national beef prices have important impacts on Hawaii beef prices and production. By using state prices rather than national prices, error from changes in freight rates might be reduced, and the model's capacity for policy analysis might be broadened.

Interest has grown in developing state econometric models for policy analysis (Knapp *et al.*). For a state agricultural model to be useful for a wide range of policy analyses, it should be able to indicate state-level impacts of changes in both state and national policies. Baum *et al.* employed such a model to analyze the impacts of U.S. beef import policy on the Virginia beef and pork sectors. However, they used national prices in their beef and hog production equations instead of Virginia prices. Such an approach can bias a state model and subsequent impact analyses. If prices are not totally transmitted within the current period, or if there is a transportation cost differential between national and state prices, the use of state prices estimated through price transmission equations might reduce that bias. Furthermore, the impact information obtainable from a state model would increase as the array of policy variables is augmented by transportation costs.

An econometric model of the Hawaii beef industry is used as a case study to demonstrate the potential improvement in impact analysis by state econometric models that use state rather than national beef and feed prices. The specific objectives of this paper are 1) to demonstrate the importance of transportation costs as determinants of Hawaii beef and feed prices; 2) to illustrate that introducing transportation costs may eliminate a specification bias and render greater reliability to subsequent impact analysis; and 3) to demonstrate the augmented policy analysis capabilities of a state agricultural commodity model that includes transportation costs and national prices in its state price transmission equations.

Hawaii provides a unique setting for examining the importance and usefulness

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of transportation costs in state commodity models. It is located about 2,500 miles from the rest of the United States. This isolation leads to a richness of data in that transportation costs are typically higher than for other states and more easily identified. Hawaii can be thought of as the extreme case. If transportation costs are not important in determining Hawaii beef and feed prices, they are unlikely to be important in determining those prices in other states.

Whether transportation costs are important price determinants is an empirical question that depends on each state's or region's location relative to major markets. For example, the Omaha utility cow price was used in the Baum *et al.* model to determine Virginia beef cattle slaughter. Whether there was a significant transportation cost differential between Omaha and Virginia utility cow prices was not addressed.

In this analysis, Hawaii beef and feed prices are estimated as a function of Los Angeles beef and corn prices and Los Angeles-to-Honolulu freight rates. Although the data and results are specific to Hawaii's beef production sector, this paper's approach can be adapted to any state or region in which prices are determined exogenously and freight charges are relatively important. A similar method may be appropriate for a number of developing nations that import a significant proportion of a commodity.

The importance of transportation costs as determinants of Hawaii beef and feed prices is stressed through regression analysis, and the Hawaii beef model is briefly outlined. Three versions of the model are simulated to emphasize differences in estimated impacts when transportation costs are not considered. The model's improved policy analysis capabilities are also demonstrated under various assumptions about changes in transportation cost variables. Finally, implications and general conclusions are drawn.

Transportation Costs as Determinants of Hawaii Prices

The Hawaii Agricultural Reporting Service estimated that 1980 beef imports from the Mainland United States and foreign sources (Australia and New Zealand) accounted for 53 and 16 percent, respectively, of total Hawaii beef market supply. However, imports to Hawaii from the Mainland were only about 0.2 percent of Mainland production and 1.3 percent of Australian and New Zealand exports to the entire United States (Schermerhorn *et al.*). Because of Hawaii's insignificance in national and international markets, Hawaii beef prices are assumed to be determined exogenously. The demand for beef in Hawaii has little impact on local beef prices. The difference between the Hawaii demand for beef and local production, at the exogenously determined price, can easily be augmented by imports from the Mainland and foreign sources. Because of the dominance of imports in the Hawaii market and the influence of the United States as a pricemaker in international beef markets (Simpson, p. 1), it follows that wholesale prices of Hawaii-produced beef should be closely related to Mainland prices and transportation costs. Similarly, the price of feed in Hawaii is assumed to be determined by Mainland price and transportation costs. On the other hand, exogenously determined prices influence production decisions in Hawaii, allowing transportation costs to affect Hawaii beef production.

Four equations were specified to reflect beef and feed price transmission from the Mainland United States to Hawaii. Explanatory variables included current and lagged Los Angeles prices and ocean freight rates from Los Angeles to Honolulu. Quarterly dummy variables were also included because seasonal variation in state, national and international beef markets were expected to influence price transmission. Each equation was first estimated by ordinary least squares. The residuals were used to calculate the Durbin-Watson statistic (DW) and a similar statistic (D4) designed to test for fourth order autocorrelation (Wallis). Where significant first order autocorrelation was indicated, a Cochrane-Orcutt autoregression procedure was used to obtain more efficient parameter estimates. Lag structures were not specified *a priori*. Therefore, in equations where lags in price transmission were hypothesized, the number of lags was determined by including successively longer lags until the coefficient of the final lag became negative or negligible relative to its standard error.

The final price transmission equations (Equations 1A–4A) are presented in Table 1. The $\bar{R}^2$ are all greater than 0.96, suggesting that the explanatory variables provide a good fit (Kmenta, p. 234). In no case does the D4 statistic indicate significant fourth order autocorrelation at the 5 percent level and seasonal effects are only significant in the grass-fed steer and heifer price transmission equation (Equation 3A).[1]

Ocean freight rates are used in Equations 1A–4A because time-series on total transportation costs for beef and feed from Los Angeles to Honolulu are not readily available. Although ocean freight costs represent a significant portion of total transportation costs, other logistics costs such as wharfage fees, land transportation costs for hauling to and from the docks, and storage can account for perhaps as much as one-half of the total cost (Garrod). Ocean freight rates can be viewed as proxies for total transportation costs because all transportation costs, whether for land or sea transportation, are highly correlated with energy and labor costs. The freight rate variables are all highly significant, with coefficients ranging from 2.27 in the Honolulu choice beef price equation (Equation 1A) to 2.57 in determining the price of grass-fed beef (Equation 3A). These coefficients appear large at first glance, but they are acceptable when one accounts for nonocean transportation costs. If the transportation cost variables in Equations 1A–4A were total transportation costs rather than ocean freight rates, the expected size of the coefficients would be about 1.0. Two conditions increase the expected size of the coefficients. First, if ocean freight costs were one-half as much as total transportation costs and if other logistics costs were highly correlated with ocean freight rates, then an increase in ocean freight rates by $1.00 per hundredweight would be accompanied by an increase in total transportation costs by $2.00. Hence, the price of beef or feed in Hawaii would increase by about $2.00 per hundredweight. Second, the ocean freight rates used in this analysis assume that containers are full, which is not always true. Partially full containers are charged a higher rate per hundredweight. Therefore, the actual rates are probably higher than the rates used, further increasing the expected size of the coefficients.

Given that certain relevant transportation cost variables are omitted, it should be clear that Equations 1A–4A are not presented as the true price transmission models. The coefficient on the Los Angeles steer price (LAGFBPRQ) in Equation 1A and the sums of the Los Angeles price coefficients in Equations 2A–4A are statistically different from unity. Divergence from unity might result from a number of things such as differences in products and levels of marketing, imperfect price transmission or specification error caused by the omission of relevant variables.

Because of local pricing mechanisms, Equation 1A most closely fits the Main-

[1] Seasonal dummy variables were retained in Equations 1A, 2A and 4A for comparison. Reestimation without quarterly dummy variables did not appreciably affect the coefficients of the remaining variables and the $\bar{R}^2$ variables only increased slightly. For example, the $\bar{R}^2$ of Equation 2A increased from 0.9847 to 0.9850 when dummy variables were dropped.

TABLE 1. Hawaii Beef and Feed Price Transmission Equations.[a]

Explanatory Variable[b]	Dependent Variable and Equation Number							
	HGFBPRQ		HCPRQ		HNFBPRQ		CFPQ	
	1A	1B	2A	2B	3A	3B	4A	4B
Intercept	−7.18	0.27	−15.61	−6.71	−6.61	2.73	−0.37	1.47
	(1.56)[c]	(1.37)	(3.98)	(3.79)	(3.50)	(2.84)	(0.25)	(0.53)
LAGFBPRQ	0.98	1.12						
	(0.03)	(0.02)						
LACPRQ			0.19	0.23	0.33	0.41		
			(0.08)	(0.08)	(0.06)	(0.06)		
LACPRQ(−1)[d]			0.43	0.47	0.31	0.37		
			(0.10)	(0.09)	(0.06)	(0.06)		
LACPRQ(−2)			0.23	0.27				
			(0.10)	(0.09)				
LACPRQ(−3)			0.09	0.14				
			(0.09)	(0.09)				
DLAGFCPRQ					0.31	0.36		
					(0.07)	(0.07)		
DLAGFCPRQ(−1)					0.14	0.22		
					(0.07)	(0.07)		
LACORNPQ							0.09	0.26
							(0.07)	(0.16)
LACORNPQ(−1)							0.28	0.26
							(0.10)	(0.23)
LACORNPQ(−2)							0.20	0.35
							(0.07)	(0.17)
TRANBQ	2.27		2.46		2.56			
	(0.37)		(0.89)		(0.90)			
TRANFQ							2.41	
							(0.20)	
D1Q	0.05	−0.32	1.25	1.14	1.67	1.55	−0.07	−0.16
	(0.59)	(0.84)	(0.99)	(0.94)	(0.71)	(0.73)	(0.15)	(0.34)
D2Q	0.06	−0.59	1.14	1.17	1.15	0.90	−0.06	−0.003
	(0.60)	(0.84)	(1.09)	(1.06)	(0.68)	(0.69)	(0.15)	(0.34)

TABLE 1. Continued.

Explanatory Variable[b]	Dependent Variable and Equation Number							
	HGFBPRQ		HCPRQ		HNFBPRQ		CFPQ	
	1A	1B	2A	2B	3A	3B	4A	4B
D3Q	0.22	−0.09	−0.90	0.05	−0.07	−0.30	−0.08	−0.09
	(0.60)	(0.84)	(0.94)	(0.92)	(0.55)	(0.55)	(0.15)	(0.34)
$\hat{\rho}$			0.46	0.69	0.53	0.69		
			(0.13)	(0.11)	(0.13)	(0.11)		
DW	1.78	1.12	1.15	0.71	1.22	1.08	1.46	0.27
D4	2.39	2.34	2.03	1.12	1.89	1.97	2.01	0.63
$\bar{R}^2$	0.996	0.993	0.985	0.984	0.988	0.986	0.967	0.826

[a] Sources of data: Hawaii Agricultural Reporting Service; Hawaii Market News Service; California Federal-State Market News Service; and Matson Navigation Company.
[b] Variable definitions are found in Table 3.
[c] Numbers in parentheses below coefficients are estimated standard errors (asymptotic standard errors for Equations 2 and 3).
[d] Numbers in parentheses following variable names indicate lags.

land price plus transportation cost model. Once a week the major Hawaii slaughterhouses call slaughterhouses in Los Angeles for price quotations. Hawaii grain-fed steer and heifer prices are based on those quotations plus a markup for transportation costs. The coefficient for the Los Angeles wholesale choice steer price (LAGFBPRQ) is close to unity (0.98) as expected.[2] The coefficient for TRANBQ and the constant term suggest that the transportation cost differential between Los Angeles and Honolulu is about 2.27 times the ocean freight rate minus $7.18 per hundredweight.

Transmission of cow prices from the Mainland to Hawaii is more complicated than for choice beef. Pricing methods are not as well defined and, because Hawaii imports large quantities of cow beef from Australia and New Zealand, price transmission from the Mainland is indirect via the Australian and New Zealand markets. Lagged Los Angeles cow prices are included in Equation 2A to capture price transmission delays caused by the great distances involved and the time required for changes in the U.S. cow price to work through the Australian and New Zealand markets to Hawaii. The sum of the coefficients on the current and lagged Los Angeles cow prices is 0.94, which is again reasonably close to unity given differences in products and the indirect transmission of prices through the Australian and New Zealand markets.

Several factors complicate transmission of grass-fed steer and heifer beef prices to

[2] The true parameter estimated by this regression coefficient would be equal to 1.00 only if the Los Angeles and Honolulu prices were for identical product and prices were perfectly transmitted. In this case, the Los Angeles price is for steers, while the Honolulu price is for steers and heifers. Therefore, the true parameter should be close to unity, but not necessarily equal to unity. The estimated coefficient is statistically different from 1.00. However, whether it is close to unity in the same sense that the true parameter is close to unity is a matter of judgment.

Hawaii. First, there are no wholesale grass-fed steer and heifer beef prices in Hawaii or on the Mainland. Second, a dressed weight price received by farmers is recorded in Hawaii but not on the Mainland. Third, as with cow beef, the Hawaii price is determined by the Mainland market via the Australia and New Zealand markets. Because Hawaii-produced grass-fed beef competes with both cow and grass-fed steer and heifer beef imported from Australia and New Zealand, it is hypothesized that Mainland steer and cow prices are both highly influential in determining the Hawaii grass-fed steer and heifer beef prices. Equation 3A uses current and lagged Los Angeles utility cow prices, and current and lagged differences between the Los Angeles choice steer price and the utility cow price, to represent the influence of the Mainland beef market on the Hawaii grass-fed steer and heifer price. The current and lagged price coefficients of Equation 3A suggest that, if both Los Angeles prices increased by $1.00, the Hawaii grass-fed beef price would increase by $0.64. An increase by $1.00 in the Los Angeles utility cow price or the Los Angeles choice steer price, holding the other price constant, would result in increases in the Hawaii grass-fed beef price of $0.19 and $0.50, respectively. These coefficients seem reasonable given differences in commodities and levels of marketing.

Mainland prices directly determine the Hawaii cattle feed price paid by farmers. Most of the feed used is manufactured in Hawaii from feed stuffs imported from the Mainland. Relatively little manufactured feed is received from the Mainland for use by cattle. Pricing methods are poorly defined. Therefore, current and lagged Los Angeles wholesale corn prices are used in Equation 4A to capture delays in price transmission from the Mainland to Hawaii and from one level in the marketing chain to another. The sum of the current and lagged price coefficients is 0.57. This is acceptable given differences in the levels of processing and marketing.

Equations 1B–4B of Table 1 are identical to Equations 1A–4A except that transportation cost variables are excluded. These equations suggest that a positive bias might be present in the price coefficients resulting from omission of relevant variables. The estimated coefficients of the transportation cost variables are positive and highly significant in Equations 1A–4A. Therefore, if prices and ocean freight rates are positively correlated, this omission would likely produce a positive bias in the price coefficients of Equations 1B–4B (Kmenta, pp. 392–95). Price variables and freight rates are highly correlated. The simple correlation coefficients between the beef freight rate and current and lagged Los Angeles beef prices are all greater than 0.80. Similarly, all correlation coefficients between the feed freight rate and current and lagged Los Angeles corn prices are greater than 0.65. The consequences of omitting freight rates are evident. Almost without exception the estimated price coefficients are larger in Equations 1B–4B than in Equations 1A–4A. This is not to say that Equations 1A–4A are without specification bias. It is clear, however, that one source of specification error is eliminated by including ocean freight rates. These findings suggest that if freight rates were omitted from a model of Hawaii beef production, subsequent impact analyses would be adversely affected. Differences in simulated impacts are addressed after the Hawaii beef model is briefly presented.

The Hawaii Beef Model

The model used for this analysis has been described in detail (Roberts *et al.*). The version used in this paper consists of 23 equations, 13 of which are behavioral relationships estimated from quarterly and annual data for 1970 through 1980. The model is divided into four sections. The first section deals with Mainland-to-Hawaii price transmission. For this analysis, Equations 1A–4A of Table 1 replace the first seven equations of Roberts *et al.* Exogenously determined Hawaii beef and feed prices and an energy price index are used in Section 2 to determine January 1 inventories of beef cows, heifers, heifers held for replacement, heifers not held for replacement, and steers. The annual calf crop is also estimated in Section 2. Section 3 uses the prices from Section 1 and the cattle inventories generated in Section 2 to estimate quarterly production of grain-fed beef, grass-fed steer and heifer beef and cow beef. For completeness, bull beef production is also estimated as a function of cow beef production. Finally, Section 4 links the other sections through period transition identities that convert quarterly prices into annual averages for use in Section 2. January 1 cattle inventories also are modified for use in the quarterly production equations of Section 3.

Exogenously determined prices greatly simplify estimation procedures. The matrix of endogenous variable coefficients is triangular, and a recursive system is assumed (Johnston). Consequently, ordinary least squares and Cochrane-Orcutt autoregression procedures (White) were used to estimate the structural equations of the model. For equations including lagged dependent variables, partial adjustment was assumed (Nerlove), and a Grid Search autoregression procedure was used to verify that the Cochrane-Orcutt procedure converged to a global maximum of the likelihood function (Betancourt and Kelejian).

Modifications of the Model for Impact Analysis

Simulations of the model over the 1972 through 1980 period are used to emphasize differences in simulated impacts and other problems resulting from the exclusion of transportation costs. Three versions of the model are used. Model I uses Equations 1A–4A to transmit prices from the Mainland to Hawaii, while Model II uses Equations 1B–4B for price transmission. All other equations are identical in Models I and II. In Model III, all inventory and production equations are reestimated, according to the specification of Models I and II, using Los Angeles beef and corn prices as regressors rather than Hawaii prices. Therefore, Model III includes no price transmission equations. The reestimated equations are presented in Table 2 for comparison with those of Roberts *et al.* Symbols are defined in Table 3. Using Los Angeles prices introduces an additional misspecification into Model III. Because there are no prices for Los Angeles grass-fed steer and heifer beef, the Los Angeles utility cow price is substituted as a proxy in the grain- and grass-fed beef production equations. Additional differences in impacts would result to the extent that a policy change or other exogenous shock affected the Los Angeles utility cow price differently from the Hawaii grass-fed steer and heifer price.

Historical Simulations of Models I–III

Before simulated impacts are measured, the relative abilities of the models in tracking historical events are assessed by comparing Theil U_2 coefficients (Leuthold).[3] The U_2 coefficients are calculated for each model by performing a dynamic simulation over the 1972 through 1980 period. Observations for 1970–71 are excluded to accommodate lags. Each simu-

[3] The U_2 coefficient is defined in this analysis as

$$U_2 = \frac{\sqrt{\Sigma[(P_t - A_{t-1}) - (A_t - A_{t-1})]^2}}{\sqrt{(A_t - A_{t-1})^2}}$$

with P_t being the predicted outcome and A_t being the actual outcome for period t.

Table 2. Estimated Equations and Identities of the Hawaii Beef Econometric Model Using National Rather Than Hawaii Prices (Model III).[a]

Equation number[b]	Equation
	I. Quarterly Price Transmission Equations[c]
	II. Annual Cattle Inventory and Calf Crop Equations
5(9)	$BCI = 16.716 + .045LAGFBPR(-1)/LACFPI(-1)$
	(35.429) (.060)
	$- .009OILP(-1)/LACFPI(-1) + .769BCI(-1),$
	(.010) (.342)
	$R^2 = .7607$, DH[d], OLS.
6(10)	$HI = -22.895 + .481CC(-1) - .046LAGFBPR(-1)/LACFPI(-1)$
	(8.549) (.095) (.016)
	$+ .012OILP(-1)/LACFPI(-1) + .759HI(-1),$
	(.002) (.120)
	$R^2 = .7942$, AUT, $\hat{\rho} = -.541.$
	(.261)
7(11)	$OHI = -5.016 + .801(HI - HHDCR) - .011LAGFBPR(-1)/LACFPI(-1)$
	(2.785) (.070) (.008)
	$- .009OILP(-1)/LACFPI(-1),$
	(.001)
	$R^2 = .9651$, AUT, $\hat{\rho} = -.432.$
	(.272)
8(12)	$HHBCR = HI - OHI - HHDCR.$
9(13)	$SI = -15.249 + .459CC(-1) - .045LAGFBPR(-1)/LACFPI(-1)$
	(10.038) (.134) (.021)
	$- .002OILP(-1)/LACFPI(-1) + .553SI(-1),$
	(.004) (.189)
	$R^2 = .8660$, AUT, $\hat{\rho} = -.392.$
	(.307)
10(14)	$CC = -34.757 + .899(BCI + DCI) + .784(HHBCR + HHDCR),$
	(24.931) (.183) (.375)
	$R^2 = .7275$, AUT, $\hat{\rho} = -.426.$
	(.273)
	III. Quarterly Beef Production Equations
11(15)	$GFBPQ = -5{,}762.6 - 78.756TSOHIQ*D1Q - 53.088TSOHIQ*D2Q$
	(1,601.2) (27.609) (20.988)
	$+ 24.960TSOHIQ*D3Q + 67.072TSOHIQ$
	(15.976) (26.428)
	$+ 62.258TSOHIQ(-4)*D1Q + 450.01RSOHIQ*D1Q$
	(24.560) (560.10)
	$+ 1{,}346.2RSOHIQ*D2Q - 958.72RSOHIQ*D3Q + 3{,}636.8RSOHIQ$
	(726.57) (542.60) (834.32)
	$+ 47.503LAGFBPRQ(-1)/LACFPIQ(-1) - 26.142LACPRQ(-1)/LACFPIQ(-1)$
	(11.835) (10.670)
	$- 5.750OILPQ(-1)/LACFPIQ(-1)$
	(1.529)
	$- 10.520[LAGFBRQ(-1)/LACFPIQ(-1) - LAGFBPRQ(-2)/LACFPIQ(-2)]$
	(6.049)

Table 2. Continued.

Equation number[b]	Equation
	+ 4.639[OILPQ(−1)/LACFPIQ(−1) − OILPQ(−2)/LACFPIQ(−2)]
	(1.675)
	+ 892.89DM1Q + 756.36DM2Q − 432.30DM3Q − 476.75WQ + 38.529TQ,
	(215.38) (190.64) (303.21) (130.69) (14.823)
	R^2 = .9499, AUT, $\hat{\rho}$ = .328.
	(.151)
12(16)	NFBPQ = 405.96 − 1.114TSOHIQ*D1Q + 4.197TSOHIQ*D2Q
	(343.01) (1.034) (.713)
	+ 2.456TSOHIQ*D3Q + 22.595TSOHIQ − 229.03RSOHIQ
	(.999) (5.095) (156.92)
	− .141GFBPQ(−3) − 11.392LAGFBPRQ(−3)/LACFPIQ(−3)
	(.031) (2.580)
	+ 9.837LACPRQ(−3)/LACFPIQ(−3) + .765OILPQ(−3)/LACFPIQ(−3)
	(2.611) (.314)
	− 44.668WQ(−3) + 247.47DM3Q + .629NFBPQ(−1),
	(31.089) (59.849) (.093)
	R^2 = .9164, AUT, $\hat{\rho}$ = −.388.
	(.157)
13(17)	TSHBPQ = GFBPQ + NFBPQ.
14(18)	CBPQ = 3,396.5 − 1.147CIQ*D1Q + 1.014CIQ*D2Q + .457CIQ*D3Q
	(981.95) (.484) (.484) (.411)
	− 17.596CIQ + 3.691[LACPRQ/LACFPIQ − LACPRQ(−1)/LACFPIQ(−1)]
	(9.282) (4.271)
	− 1.825[LAGFBPRQ/LACFPIQ − LAGFBPRQ(−1)/LACFPIQ(−1)]
	(3.532)
	− 8.743TQ + 75.779WQ,
	(3.216) (47.959)
	R^2 = .6013, AUT, $\hat{\rho}$ = .380.
	(.141)
15(19)	BBPQ = 36.171 + .046CBPQ + 44.798D1Q + 20.981D2Q
	(64.666) (.038) (15.8148) (15.920)
	+ 31.267D3Q + .459BBPQ(−1),
	(15.296) (.142)
	R^2 = .3190, DH = −.851, OLS.
16(20)	TBPQ = TSHBPQ + CBPQ + BBPQ.
	IV. Period Transition Identities
17(21)	$LACFPI(L)^e = .25 \sum_{t=1}^{4} LACFPIQ(t).$
18(22)	$LAGFBPR(L) = .25 \sum_{t=1}^{4} LAGFBPRQ(t).$
19(23)	$OILP(L) = .25 \sum_{t=1}^{4} OILPQ(t).$
20(24)	CIQ(t = 1–4) = BCI(L) + DCI(L).

Table 2. Continued.

Equation number[b]	Equation
21(25)	TSOHIQ(t = 1–4) = SI(L) + OHI(L).
22(26)	RSOHIQ(t = 1–4) = SI(L)/OHI(L).

[a] In the autoregressive equations (AUT), R^2 is viewed only as a measure of goodness-of-fit (Kmenta, p. 234). Numbers in parentheses below coefficients are estimated standard errors (asymptotic standard errors for AUT equations). Numbers in parentheses following variable names indicate lags. Variables are defined in Table 3.
[b] Numbers in parentheses following equation numbers indicate the corresponding equation in Roberts *et al.*
[c] Price transmission equations are not used in this version of the model.
[d] Calculation of Durbin's h statistic was not possible.
[e] L refers to the current year and t refers to the quarter of that year.

lation is performed by allowing the model to iterate, with exogenous variables set at historical levels and lagged endogenous variables set at predicted values. These simulations are used as bases for calculating simulated impacts in the next section.

The U_2 coefficients calculated from the models are presented in Table 4. When comparing models, lower U_2 coefficients indicate greater accuracy. The U_2 coefficients are lower for Model I than for Models II and III, with the exception of bull beef production (BBPQ), for which the U_2 coefficient is lowest for Model II. In no case is the U_2 coefficient smaller for Model III than for Models I or II. These comparisons demonstrate (1) that the exclusion of transportation costs from the price transmission equations substantially decreases the accuracy of the model and (2) that elimination of price transmission equations further reduces the model's goodness-of-fit to historical data.[4]

[4] The inventory and production equations of Models I and II were theoretically specified and adjusted according to goodness-of-fit criteria (eg., $\bar{R}^2$, standard error and signs of the coefficients) and data availability. Had the same criteria been used to adjust the inventory and production equations of Model III, it is possible that a better fitting model, with a different structure, would have been developed. However, given the exclusion of freight rates, the lack of a Los Angeles grain-fed steer and heifer price, and other data limitations, it is unlikely that such a model would have U_2 coefficients lower than those of Model I.

Differences in Impacts

Several additional simulations are conducted to emphasize differences in simulated impacts among the models. Subsequent simulations for a particular model are compared to their respective bases. Impacts are defined as deviations from the base. Three additional simulations are performed with each model. Each additional simulation increases one of the three Los Angeles prices by 10 percent above annual historical levels, while other variables are kept at base values.

Table 5 contains the simulated impacts of key variables, averaged over the simulation period (1972–80) to conserve space. Before impacts are compared among the models, it is helpful to describe briefly the impacts produced by Model I. Generally, the average impacts for Model I are as expected. An increase in the Los Angeles choice steer price (LAGFBPRQ) of \$8.10 for the 1972–80 period results in increases of \$8.00 and \$3.70 in the Honolulu choice beef price (HCFBPRQ) and the Hawaii grass-fed steer and heifer price (HNFBPRQ), respectively. Thus, HGFBPRQ increases relative to HNFBPRQ, resulting in an increase in grain-fed beef production (GFBPQ) of 1,059,000 pounds and decrease in grass-fed steer and heifer beef production (NFBPQ) of 277,000 pounds below base levels for 1972–80. Cow beef production (CBPQ) also decreases an average of

195,000 pounds as ranchers, responding to increased profit incentives, build the cow herd (BCI) by reducing the culling rate. The net result is a 671,000 pound increase above base levels in Hawaii beef production (TBPQ) for the 1972–80 period.

A $6.50 average increase in the Los Angeles utility cow price (LACBPRQ) results in an increase in the Hawaii grass-fed beef price (HNFBPRQ) relative to the Honolulu choice beef price (HGFBPRQ). Consequently, Hawaii grain-fed beef production (GFBPQ) decreases by 214,000 pounds below base levels and grass-fed beef production (NFBPQ) increases 228,000 pounds above base levels for 1972–80. Cow beef production (CBPQ) decreases only slightly, and the effect on total beef production (TBPQ) is negligible (24,000 pound increase averaged over the simulation period). Beef cow inventory is not affected by the increases in the Los Angeles cow price because the Honolulu utility cow price was found not to be a significant factor in explaining the size of the Hawaii cow herd. Therefore, it was excluded from the model's beef cow inventory equation.

The Hawaii cattle feed price (HCFPRQ) increases an average of $0.50 above base levels when the Los Angeles corn price increases an average of $0.80. Thus, the feed price increases relative to all beef prices, causing changes in the composition of beef production. The signs of the average impacts on grain-fed (GFBPQ) and grass-fed (NFBPQ) beef production appear incorrect. However, the dynamics of the Hawaii beef industry explain the result. When the feed price increases, Hawaii ranchers reduce the size of the cow herd (BCI) by increasing the culling rate (CBPQ) and reducing the replacement rate. The smaller cow herd produces fewer feeder calves available to be placed on feed or grass. The number of feeder calves placed on grass decreases, accounting for most of the reduction in the calf crop, and the number placed on feed remains fairly constant. A possible explanation is that a few large ranches in the state also own the feedlot and slaughter facilities on Oahu, giving them a vested interest in maintaining feedlot and slaughter volume.

Comparing the impacts of Model II with those of Model I reveals the effects of excluding ocean freight rates from the price transmission equations. The average impact for 1972–80 on the Honolulu choice beef price (HGFBPRQ), resulting from a 10 percent increase in the Los Angeles choice steer price (LAGFBPRQ), is 14 percent greater for Model II than Model I, and the average impact on the Hawaii grass-fed beef price (HNFBPRQ) is 24 percent higher. The higher price impacts filter through the system, causing larger impacts on beef production and cow inventory in Model II than Model I. For example, in Model II the 1972–80 average impact on grass-fed steer and heifer beef production (NFBPQ) is 16 percent larger than in Model I, and the average impact on grain-fed beef production is 13 percent larger.

Similar events occur when the Los Angeles utility cow and corn prices increase by 10 percent. When the Los Angeles utility cow price (LACPRQ) increases by 10 percent, the average impacts in Model II on the Hawaii grass-fed price (HNFBPRQ) and the Honolulu utility cow price (HCPRQ) are 18 and 19 percent larger, respectively, than in Model I. The exclusion of the feed freight rate results in a 40 percent difference in the 1972–80 average impacts on the Hawaii cattle feed price (CFPQ) when the Los Angeles corn price (LACORNPQ) increases by 10 percent.

The average impacts from Model III, in which Los Angeles beef and corn prices are used directly, are markedly different from those of Model I. Again, the cause is differences in model specification. Los Angeles prices are not the prices Hawaii ranchers face. Nor are they good proxies, because transportation costs and lags in

TABLE 3. Variable and Symbol Definitions.[a]

Variable or Symbol	Definition
	Variables
BBPQ	Bull beef production (dressed weight, 1,000 pounds).
BCI	Beef cow inventory (January 1, 1,000 head).
CBPQ	Cow beef production (dressed weight, 1,000 pounds).
CC	Calf crop (1,000 head).
CFPQ	Cattle feed price (paid by Hawaii ranchers, $/100 pounds).
CI	Beef plus diary cow inventory (January 1, 1,000 head).
CIQ	Beef plus diary cow inventory (January 1 inventory for each quarter of the current year, 1,000 head).
D1Q	Equals 1 in the first quarter and 0 otherwise.
D2Q	Equals 1 in the second quarter and 0 otherwise.
D3Q	Equals 1 in the third quarter and 0 otherwise.
DCI	Dairy cow inventory (January 1, 1,000 head).
DLAGFCPRQ	Equals LAGFBPRQ − LACPRQ.
DM1Q	Price freeze dummy, equals 1 for 1973 (II)–1973 (III).
DM2Q	Pre-trailer freight regulation dummy, equals 1 for 1976 (I)–1977 (II).
DM3Q	Post-trailer freight regulation dummy, equals 1 for 1978 (IV)–1980 (IV).
GFBPQ	Grain-fed steer and heifer beef production (dressed weight, 1,000 pounds).
HCPRQ	Honolulu cow price (wholesale, all carcasses, utility, $/100 pounds).
HGFBPR	Honolulu grain-fed beef price (annual average of HGFBPRQ).
HGFBPRQ	Honolulu grain-fed beef price (wholesale, 500–900 pound carcasses, choice feedlot steers and heifers, $/100 pounds).
HHBCR	Heifers held for beef cow replacement (January 1 inventory, 1,000 head).
HHDCR	Heifers held for dairy cow replacement (January 1 inventory, 1,000 head).
HI	Heifer inventory (January 1, 1,000 head).
HNFBPRQ	Hawaii grass-fed beef price (dressed weight, steers and heifers, $/100 pounds).
LACFPI	Los Angeles cattle feed price index (annual average of LACFPIQ).
LACFPIQ	Los Angeles cattle feed price index (LACORNPQ converted to an index with 1980 = 1).
LACORNPQ	Los Angeles corn price (wholesale, $/100 pounds).
LACPRQ	Los Angeles cow price (wholesale, 350–700 pound carcasses, utility, $/100 pounds).
LAGFBPR	Los Angeles grain-fed beef price (annual average of LAGFBPRQ).
LAGFBPRQ	Los Angeles grain-fed beef price (wholesale, 600–700 pound carcasses, choice steers, $/100 pounds).
NFBPQ	Grass-fed steer and heifer beef production (dressed weight, 1,000 pounds).
OHI	Other heifer inventory, i.e., heifers not held for beef or dairy cow replacement (January 1, 1,000 head).
OILP	U.S. crude oil wholesale price index (annual average of OILPQ).
OILPQ	U.S. crude oil wholesale price index (1967 = 100.0).
RSOHIQ	Ratio of steer to other heifer inventory (January 1 inventories for each quarter of the current year).
SI	Steer inventory (January 1, 1,000 head).
TBPQ	Total beef production (dressed weight, 1,000 pounds).
TQ	Time, equals 1 in 1970 (I) to 44 in 1980 (IV).
TRANBQ	Cost of transporting beef from the U.S. West Coast to Hawaii in containers ($/100 pounds).
TRANFQ	Cost of transporting animal feeds and feed ingredients from the U.S. West Coast to Hawaii in containers ($/ton).
TSHBPQ	Total steer and heifer beef production (dressed weight, 1,000 pounds).
TSOHIQ	Steer plus other heifer inventory (January 1 inventories for each quarter of the current year, 1,000 head).
WQ	Weather dummy, equals 1 in quarters when droughts occurred.
	Other Symbols
R^2	One minus the ratio of the sum of squares residual to the sum of squares total (calculated from untransformed data for autoregressive equations).

TABLE 3. Continued.

Variable or Symbol	Definition
DW	Durbin-Watson statistic.
DH	Durbin h statistic.
OLS	Ordinary least squares.
AUT	Autoregression procedure (Cochrane-Orcutt or Grid Search).
$\hat{\rho}$	Estimated first order autoregressive parameter.

[a] Q at the end of a variable name denotes quarterly observations. All other variables are annual.

price transmission are not considered. Also, the Los Angeles utility cow price is used in the grain- and grass-fed beef production equations as a proxy for the return to producing grass-fed steers and heifers. Under this specification, Model III overestimates the absolute impacts from an increase in the Los Angeles choice steer price because no offsetting increase in the Hawaii grass-fed beef price exists that is analogous to the increases implicit in Models I and II. Likewise, when the Los Angeles utility cow price increases, the effects are larger in Model III than if Equations 3A and 3B were used for price transmission.

Differences in average impacts over the simulation period caused by excluding transportation costs from the Mainland-to-Hawaii price transmission equations seem substantial. Those differences are even larger when the price transmission equations are excluded and Los Angeles prices are used directly.[5] These findings cast serious doubt on the reliability of Models II and III in evaluating how changes in national agricultural policies concerning Mainland beef and feed grain prices affect the Hawaii beef industry. The reliability of such models in evaluating the impacts of changes in state-level policy instruments also would be questionable.

[5] It is important to remember that differences in average impacts are not related to how accurately each model explains historical data. Rather, they are a direct result of differences in the magnitudes of the estimated coefficients caused by the omission of freight rates or the substitution of Los Angeles prices for Honolulu prices.

Augmented Policy Analysis Potential

The results of two additional simulations of Model I are presented in Table 6 to demonstrate the model's added potential for policy analysis if transportation costs are included in price transmission equations. A 10 percent increase in beef freight rates (TRANBQ) above actual levels for each year between 1972 and 1980 causes all Hawaii beef prices to increase. However, both the Hawaii grass-fed steer and heifer price (HNFBPRQ) and the Honolulu utility cow price (HCPRQ) increase relative to the Honolulu choice steer and heifer price (HGF BPRQ). Consequently, grain-fed beef production (GFBPQ) decreases in 1972–75, while grass-fed beef production

TABLE 4. Theil U_2 Coefficients for Models I–III, 1972 (I)–1980 (IV).

	Model I	Model II	Model III
HGFBPRQ	0.193	0.274	—
HNFBPRQ	0.486	0.599	—
HCPRQ	0.529	0.630	—
CFPQ	0.657	1.550	—
GFBPQ	0.572	0.661	0.781
NFBPQ	1.333	1.494	1.808
TSHBPQ	0.810	0.958	0.965
CBPQ	0.602	0.641	0.726
BBPQ	0.881	0.862	0.908
TBPQ	0.831	0.976	0.997
BCI	0.617	0.841	1.126
CI	0.586	0.798	1.068
HI	0.529	0.676	0.875
OHI	0.614	0.869	0.960
HHBCR	0.533	0.549	1.019
SI	0.621	0.818	0.903
CC	0.707	0.800	0.887

TABLE 5. Average 1972–80 Simulated Impacts for Models I–III Resulting from a 10 Percent Increase in One Los Angeles Price, Holding Others at Historical Levels.

		Model I	Model II		Model III	
Variable[a]	1972–80 Historical Average (units)[b]	Impact (units)[b]	Impact (units)[b]	Percentage Change from Model I	Impact (units)[b]	Percentage Change from Model I
		Increase LAGFBPRQ 10% ($8.10)				
HFGBPRQ	90.60	8.00	9.10	14	—	—
HNFBPRQ	63.60	3.70	4.60	24	—	—
GFBPQ	18,657	1,059	1,194	13	1,949	84
NFBPQ	5,239	−277	−234	16	−1,780	−543
CBPQ	5,720	−195	−217	−11	−75	62
TBPQ	30,546	671	725	8	88	−87
BCI	86.0	2.8	3.1	11	1.0	−64
		Increase LACPRQ 10% ($6.50)				
HNFBPRQ	63.60	1.10	1.30	18	—	—
HCPRQ	65.40	5.80	6.90	19	—	—
GFBPQ	18,657	−214	−251	−17	−822	−284
NFBPQ	5,239	228	263	15	992	335
CBPQ	5,720	9	12	33	3	−67
TBPQ	30,546	24	26	8	173	620
BCI	86.0	0.0	0.0	0	0.0	0
		Increase LACORNPQ 10% ($0.80)				
CFPQ	8.50	0.50	0.70	40	—	—
GFBPQ	18,657	15	69	360	57	280
NFBPQ	5,239	−122	−161	−32	141	216
CBPQ	5,720	74	104	41	28	−62
TBPQ	30,546	−28	20	171	228	914
BCI	86.0	−1.1	−1.6	−46	−0.4	−64

[a] Variables are defined in Table 3.
[b] The units are dollars per hundred pounds for HGFBPRQ, HNFBPRQ, HCPRQ, and CFPQ, thousands of pounds for GFBPQ, NFBPQ, CBPQ, and TBPQ, and thousands of head for BCI.

(NFBPQ) increases. After 1975, the impact on GFBPQ becomes positive, and the positive impact on NFBPQ becomes larger as the increasing cow herd (BCI) produces more calves. The cow herd grows with a decrease in the culling rate, as indicated by the decline in cow beef production (CBPQ). The impact on total beef production (TBPQ) is negative in the first two years but reaches a level of 1.46 percent in 1980, reflecting the increase in the calf crop.

A 10 percent increase in the cost of transporting corn to Hawaii causes the Hawaii feed price (PCFQ) to increase relative to all beef prices. As a result, cows are culled at a faster rate, causing cow beef production (CBPQ) to increase and beef cow inventory (BCI) to decrease. The decrease in BCI eventually causes a reduction in the calf crop. As the number of feeder calves decreases, the production of grass-fed steer and heifer beef (NFBPQ) decreases more than production of grain-fed beef (GFBPQ), reflecting the vested interest of ranchers in maintaining feedlot and slaughter volume.

The importance of these simulations is that the impacts result from changes in Los Angeles-to-Honolulu transportation costs. Such an analysis would have been difficult if Los Angeles prices had been used directly or if transportation costs had been excluded from the price transmission equations. These simulations demonstrate the model's potential usefulness to beef producers, state policymakers, and others interested in the effects of transportation costs on the Hawaii beef industry. For example, this model could easily be modified to evaluate the possible consequences of freight rate increases proposed by major freight carriers. Also, the impacts of deregulation could be simulated under various assumptions about freight rate adjustments resulting from such action. An example of this type of analysis was done by Roberts *et al.* who evaluated the impacts of energy price increases on the Hawaii beef industry.

Summary and Conclusions

This study demonstrates that transportation costs are important in determining beef and feed prices in Hawaii. Beef and feed transportation costs variables are highly significant when used in conjunction with Los Angeles beef and corn prices in Mainland-to-Hawaii price transmission equations. Because of their importance in price transmission and their high positive correlation with Los Angeles beef and feed prices, exclusion of transportation costs leads to a positive bias in the Los Angeles price coefficients. Larger coefficients yield larger absolute impacts, putting in question the usefulness of such a model (Model II) for policy impact analysis. The magnitudes of the simulated impacts increase even further when price transmission equations are eliminated and Los Angeles prices are used (Model III) rather than Hawaii prices.

The inclusion of freight rates and Hawaii beef and feed prices in the Hawaii beef model (Model I) is not purported to eliminate all specification bias. Obviously, the unavailability of certain transportation cost variables, and other data limitations, restrict the model's structure. However, in the case of the Hawaii beef industry, more appropriately specified price transmission equations improve the accuracy of the model and confidence in its results. The usefulness of the model is also enhanced as the number of exogenous variables is increased to include freight rates. Thus, by including transportation cost variables, changes in transportation policy or proposed rate changes by major carriers could be evaluated.

Data limitations constrain specification and estimation of most econometric models. Therefore, the results presented here should be qualified by recognizing that Model I is not without error and that Models II and III were estimated according to different criteria than Model I. Model I was specified according to theory, but respecified and estimated with an acceptable structure that provided a good fit to the limited data. On the other hand, Models II and III were specified and estimated with the same structure and statistical techniques as Model I, except for the deletion and substitution of certain variables. Therefore, the differences in impacts presented here should be interpreted as partial results because they show differences caused by the deletion of transportation cost variables or the substitution of Los Angeles prices for Honolulu prices, holding model structure and estimation techniques constant. If the models had been specified and estimated independently, the total difference in impacts would have been the difference resulting from deletion or substitution of certain variables plus the difference resulting from changes in model structure and estimation techniques. Independent specification and estimation probably would have produced models fitting the data better than Models II and III. It is unlikely, however, that such models would have performed better than Model I given the exclusion of transportation cost variables that have been shown to be significant determinants of Hawaii beef and feed prices.

Notwithstanding these qualifications and the specificity of the results to the

TABLE 6. Estimated Price and Production Percentage Impacts from Model I when Beef or Feed Ocean Freight Rates are Increased from Actual Levels by 10 Percent Each Year.

		Year								
Simulation	Variable	1972	1973	1974	1975	1976	1977	1978	1979	1980
Model I	HGFBPRQ	65.30	78.50	81.30	87.90	77.40	79.80	97.20	121.10	128.20
Base	HNFBPRQ	46.20	55.30	57.80	58.40	56.30	56.40	67.70	84.10	89.10
	HCPRQ	46.30	59.00	60.40	49.60	56.90	55.40	69.50	94.10	96.30
	CFPQ	5.50	6.50	8.50	9.10	9.10	8.60	8.70	9.60	10.60
	GFBPQ	19,658	20,236	19,487	17,962	20,627	19,740	18,343	17,327	14,462
	NFBPQ	5,306	4,820	4,013	4,403	4,635	4,940	4,904	6,799	7,272
	CBPQ	6,257	6,163	5,424	5,868	5,747	5,784	5,983	5,706	5,488
	TBPQ	32,156	32,193	29,847	29,671	31,956	31,404	30,184	30,774	28,140
	BCI	89.4	90.4	91.4	88.5	86.0	82.5	80.2	80.3	81.5
TRANBQ	HGFBPRQ	2.1	1.9	2.1	2.0	2.3	2.3	2.0	1.7	1.8
Increased	HNFBPRQ	3.4	3.2	3.4	3.4	3.6	3.7	3.2	2.9	3.0
10%	HCPRQ	3.4	2.9	3.2	3.9	3.5	3.7	3.1	2.5	2.7
	GFBPQ	−0.5	−0.6	−0.3	−0.0	0.3	0.5	0.6	0.7	1.1
	NFBPQ	0.3	2.4	3.7	3.4	4.3	4.8	5.6	4.5	4.5
	CBPQ	0.3	−0.4	−0.7	−0.7	−0.8	−0.9	−1.0	−1.1	−1.3
	TBPQ	−0.2	−0.1	0.1	0.4	0.6	0.9	1.0	1.2	1.5
	BCI	0.0	0.3	0.6	0.7	0.9	1.0	1.1	1.2	1.3
TRANCQ	CFPQ	4.5	4.0	3.5	3.4	4.0	4.5	4.6	4.6	4.6
Increased	GFBPQ	−0.2	0.3	0.3	−0.1	−0.3	−0.3	−0.1	0.2	0.6
10%	NFBPQ	−0.0	1.6	1.6	−0.8	−2.2	−3.6	−4.3	−3.3	−3.5
	CBPQ	−0.2	0.6	1.2	1.1	1.1	1.2	1.1	1.5	1.8
	TBPQ	−0.2	0.6	0.6	0.1	−0.3	−0.05	−0.5	−0.4	−0.2
	BCI	0.0	−0.6	−0.9	−1.1	−1.2	−1.2	−1.4	−1.5	−1.7

Hawaii beef industry, the results suggest that researchers be cautious in using national rather than state price variables in state commodity models. When state prices are exogenously determined by national or major regional market prices, it is an empirical question whether transportation costs are important in price transmission. These results might encourage other state econometric modelers to try to improve the accuracy and usefulness of their agricultural models by including transportation cost variables in their models where appropriate.

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