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PUZZLES FOR AGRICULTURAL ECONOMISTS IN THE 1980's

Luther Tweeten

The role of the economist is to identify and solve puzzles. Unsolved puzzles seem to crop up more frequently these days or perhaps my ability to solve them has diminished. The purpose of this paper is to set forth selected enigmas in hope that someone (perhaps a bright, young mind who fails to appreciate the intractability of the problem) will find solutions. I begin with national macroeconomic policy, then turn to international economics. After looking at past trends in supply and demand for farm output, I conclude with sections on farm investment behavior and the role of the agricultural economist in an affluent farming economy.

NATIONAL ECONOMIC POLICY

The Reagan Administration is responding to widespread public sentiment for new directions in national economic policy with a curious mixture of neo-classical supply-side economic, monetarism, and neo-Keynesian deficit spending (see Tweeten, December, 1980b). I applaud greater emphasis on money supply and the price system along with the need to restrain growth in government spending and regulations.

But a case can be made for more deliberate movement toward a balanced budget. The neo-Keynesian strategy of continuing large annual deficits to stimulate the economy works at cross purposes with monetary restraint to reduce aggregate demand and inflation. The economic engine, like an auto engine, does not function efficiently when brake and accelerator are applied simultaneously. Unless financed by inflationary expansion of money supply, deficits increase competition for money, drive up interest rates and crowd out private investment. The public seems ready for a bold experiment in supply-side economics, but the Administration seems unwilling to take the leap. It is not possible to determine if supply-side economics works when it is conflated with neo-Keynesian economics.

In my judgment, the potential of our fundamentally strong but underachieving national economy will not be realized until structural problems are confronted such as power of labor unions to impose contracts calling for hefty wage increases — often 10 percent per year for each of three years. Imperfect competition in industry is less of a problem today than in earlier times because of exposure of firms to international competition. If wage and price controls are

are considered to alleviate core inflation, now about 9 percent per year, it is well that they be restricted to wages and salaries so as to break core inflation and the wage side of the wage-price spiral while creating opportunities for profit and investment in industry.

The puzzle for economic policy is to find a combination of programs that will provide acceptable tradeoffs between unemployment and economic progress while restraining inflation. Is the political will sufficient to deal with structural elements such as labor unions which perpetuate the core inflation rate? Are two to three years of wage and salary controls (not price controls) necessary to reduce the core inflation rate to acceptable levels as proposed by Starleaf? I do not know the answers to this puzzle but am pessimistic about chances that the public will back policymakers who must make the hard choices necessary to create wage and price flexibility and reduce the core inflation rate to say 3 percent per year.

INTERNATIONAL ECONOMY

It has become trite to emphasize the interdependence of our economy in a world of emerging strong economies capable of competing effectively for world markets and of conducting monetary-fiscal policy that buffets our economy. The ramifications for the U.S. farming industry of an underachieving economy characterized by high inflation rates have been analyzed in some detail for real-wealth (Boyne), cost-price (Tweeten, December, 1980a) and cash-flow (Tweeten, July, 1981) effects. What is not clear is the feedback of an underachieving economy through international trade and capital flows. Our neo-Keynesian policies that encourage consumption, discourage savings and investment and stimulate inflation encourage trade deficits that weaken the dollar in world markets. The first impact of inflation is to make our goods, including farm products, more expensive abroad. Ensuing trade deficits and excess supplies of dollars abroad soon weaken the dollar and enhance the attractiveness of farm exports to foreign buyers. Thus farmers may benefit from neo-Keynesian policies by virtue of lower real prices of our farm products in foreign markets and greater exports from the farming industry which enjoys a comparative advantage in world trade. Sound monetary-fiscal policy to reduce inflation and strengthen the dollar in world markets has the opposite effect. Could it be that cost-price and cash-flow benefits to farmers from a stable general price level would be more than offset by lessened ability of our farm products to compete in world markets? I do not know the answer, but feel this is a frontier area for economic research.

DEMAND AND SUPPLY SHIFTS IN RETROSPECT

I now turn to some puzzling results from analysis of trends in real demand and supply of

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farm output since 1950. Computations by Damona Doye of annual shifts in aggregate real demand and supply curves of farm output shown in Tables 1 and 2 raise more questions than they answer. (See Appendix for conceptual framework).

Shifts in demand are computed from changes in population, exports and real per capita income (Council of Economic Advisors). Variables that shift real demand are measured with considerable accuracy. The income elasticity of demand is less accurately measured and is here assumed to be .1 for the entire 1950-79 period. Alternative elasticities of up to .2 made only minor differences in results. Real supply shifts are measured by annual changes in the USDA productivity index (USDA, February 1981) which is characterized by numerous conceptual and operational data problems. The implication is that real demand shifts probably are measured with considerable error.

The conundrum in Table 2 is that on the average real demand is estimated to increase faster than real supply in each of the three decades since 1950. If that is the case, why did the parity ratio (prices received divided by prices paid by farmers) decline quite sharply in the 1950's and 1960's and only modestly increase in the 1970's?

The following hypotheses are offered to explain the enigma:

- (1) The price elasticities of supply and demand for farm output are greater than commonly believed. Some years ago, I (1967) calculated the price elasticity of demand for farm output to be the conventional $-.2$ in the short run but unconventional -1.1 in the long run and later with Quance (1969) calculated the price elasticity of supply of farm output to be the conventional $.1$ in the short run but unconventional 1.0 in the long run. Higher price elasticities mean less impact of shifting demand and supply on price. This hypothesis alone cannot explain the results in Table 2 if the demand and supply shifts are estimated correctly. Even if the unitary long-run price elasticities were applied, the average annual excess demand growth in the 1950's and 1960's would result in an increase rather than the decrease in real prices shown in Table 2. Similar anomalies are apparent for other decades. Additional hypotheses must be introduced to explain results in Tables 1 and 2.

The second hypothesis is that inflation exerts a real price effect on farm output, shifting upward the nominal demand curve less than the nominal supply curve and reducing the parity ratio. Tweeten and Griffin found that national inflation shifted upward nominal supply more than nominal demand so that a 1 percent increase in the general price level reduced the parity ratio by up to 1 percent in the period 1920-69. More refined analysis (Tweeten, December, 1980a) that controlled more variables revealed a much lower elasticity with each 1 percent increase in the general price level reducing the parity ratio approximately .3 percent in the 1963-78 period. The inflation hypothesis alone or in

conjunction with the high price elasticity hypothesis also seems inadequate to explain results in Tables 1 and 2.

- (3) The third hypothesis is that gains in the productivity rate and hence annual increases in real supply are underestimated. The ratio would be underestimated either because (a) aggregate input gains were overestimated and/or because (b) aggregate output gains were underestimated. A rather thorough examination of the productivity index by Gardner et al. revealed no major conceptual or empirical flaws. Questions remain and thorough analysis will be required to determine the contribution of the above hypotheses as well as others to the questions raised by data in Tables 1 and 2.

Data in Tables 1 and 2 also allow examination of changes in variability of demand and supply of farm output since 1950. Absolute annual changes in demand and supply were, among the three decades, largest on the average in the 1970's and lowest in the 1960's (Table 2). Commodity programs probably reduced variability in supply but it is of interest that the average variability in supply was approximately the same in the 1960's as in the 1950's despite less production control in the 1950's. As revealed by the parity ratio, the relatively higher market volatility in the 1950's and especially in the 1970's than in the 1960's traces more to variability in demand than in supply. Hence greater stability in the 1960's traces less to supply, which was influenced by commodity programs, than to demand which was little influenced by commodity programs. High variability in the 1970's was to no small extent a product of the growing share of volatile exports in farm demand.

Economic impacts on farm markets would be minimal under equal average shocks to demand and supply if the shocks were perfectly and negatively correlated. To determine the net shock, excess demand is shown as the annual percentage change in demand minus the percentage change in supply. The largest shock in the years shown originated mainly from supply and occurred between 1957 and 1958. On the whole, however, excess demand shocks were greater in the 1970's than in previous decades.

Absolute annual average changes in excess demand overestimate uncertainty to farm markets to the extent that average changes are part of a predictable upward trend that does not surprise market participants. To compensate, variability may be measured by an uncertainty index calculated as absolute average excess demand minus algebraic average excess demand. By this measure, the uncertainty index increased from $3.11 - .33 = 2.78$ percent in the 1950's and 2.07 percent in the 1960's to 3.54 percent in the 1970's. Although differences among decades are much lower when measured in this manner rather than by absolute annual average change in excess demand, still uncertainty was 71 percent larger in the 1970's than in the 1960's based on the uncertainty index. Growing instability is also apparent in greater variation in the parity ratio in the 1970's than in previous decades. But useful measures of the precise role of exports and other

Table 1: Annual Changes in Aggregate Real Demand, Supply, Excess Demand, and the Parity Ratio, 1950/51-1978/79.

Year	Real Demand	Real Supply	Excess Demand	Parity Ratio
(Annual Percentage Change)				
1950/51	3.7567	.0000	3.7567	6.618
1951/52	.0435	4.2253	-4.1818	-6.897
1952/53	.6603	1.3514	-.6911	-5.926
1953/54	2.3045	1.3333	.9712	-2.500
1954/55	3.4860	2.6316	.8544	-7.143
1955/56	6.5992	2.5641	4.0351	.000
1956/57	2.9812	.0000	2.9812	-1.786
1957/58	-.2688	8.7500	-9.0188	3.636
1958/59	2.6981	.0000	2.6981	-4.386
1959/60	5.3260	3.4483	1.8777	-1.835
1960/61	1.5002	1.1111	.3891	.000
1961/62	1.3498	1.0989	.2509	.000
1962/63	3.1577	4.3478	-1.1901	-1.869
1963/64	4.1172	-1.0417	5.1589	-2.857
1964/65	.9354	3.2632	-4.3278	1.961
1965/66	2.3438	-3.0000	5.3438	2.885
1966/67	.0582	3.0928	-3.0346	-6.731
1967/68	1.0720	2.0000	-.9280	-1.000
1968/69	.1113	.9804	-.8691	-1.010
1969/70	4.1505	-.9709	5.1214	-2.000
1970/71	1.1067	7.8431	-6.7364	-1.020
1971/72	3.8417	.0000	3.8417	5.208
1972/73	7.4929	.9091	6.5838	22.772
1973/74	-1.3792	-5.4054	4.0262	-5.645
1974/75	.8414	9.5238	-8.6824	-11.966
1975/76	3.9896	.0000	3.9896	-5.825
1976/77	1.3224	-.8696	2.1920	-6.186
1977/78	6.7414	1.7344	4.9870	5.495
1978/79	2.5042	2.5862	-.0820	1.042

Source: See text

Table 2: Summary of Annual Average Changes in Real Demand, Supply and The Parity Ratio by Decade, 1950/51-1978/79

Item	Total Period	Component Periods		
	1950/51- 1978/79	1950/51- 1959/60	1960/61- 1969/70	1970/71- 1978/79
(Annual Percentage Change)				
Algebraic average increase in demand	2.51	2.76	1.88	2.94
Algebraic average increase in supply	1.85	2.43	1.29	1.81
Absolute average change in demand	2.62	2.81	1.88	3.25
Absolute average change in supply	2.49	2.30	2.29	2.92
Algebraic average increase in excess demand	.66	.33	.59	1.13
Algebraic average increase in parity ratio	-.88	-2.02	-1.06	.43
Absolute average change in excess demand	3.52	3.11	2.66	4.67
Absolute average change in parity ratio	2.35	4.07	2.03	7.24

Source: See text

factors in instability have yet to be calculated. Also, economic analysis is awaited to devise appropriate public policy to deal with growing instability arising especially from demand. The benefits of stabilization policies shift from producers to consumers as instability arises increasingly from demand rather than supply (Tweeten, 1979, Ch. 7).

Farm Investment Behavior

This paper next focuses on some hypotheses regarding farm investment behavior and implications for the structure of the farming industry, particularly farm size, numbers, and tenure.

Preliminary research by Elton Li and Stan Rogers helps resolve some issues while raising others. They find Friedman's permanent income hypothesis to be a useful conceptual framework to explain farm investment behavior. Farmers have high propensities to invest out of transitory positive income and low propensities to invest (or disinvest) out of permanent and negative transitory income. The implication is that unstable farm income of a given magnitude generates more investment than stable income of the same average magnitude. Research to date indicates that commodity programs, by reducing variability in income and hence transitory income, reduce investment, other things equal. This transitory income effect on investment does not seem to be offset by higher average incomes generated by commodity programs. The research has not yet traced through the structural impact of commodity programs but the hypothesis is that less investment reduced substitution of capital for labor and restrained somewhat the outmigrati-

tion from farms. Empirical support for this hypothesis would strengthen the case that commodity programs help retain people in farming, a perception prominent among farmers. This hypothesis is also supported by the proposition that commodity programs retained people in farming by avoiding illiquidity and foreclosure. Commodity programs such as for tobacco helped some marginal farms to survive and reduced economies of size (flattened the unit cost curve when government payments are included with receipts or output). The position of many economists on the other hand is that commodity programs have speeded creation of larger and fewer farms because the programs provided sizable payments to big farms and security needed to leverage equity to form larger farming units. The puzzle is the lack of a good measure of the net impact of commodity programs on farm structure. My tentative conclusion is that the net impact of programs was small.

The behavior of farming investment poses additional puzzles for economists. In the 1970's, farm operators' gross investment in dwellings, land improvements, vehicles, machinery, and equipment averaged nearly one-third of their personal income (U.S. Department of Agriculture, December 1980). A portion of this was financed with debt capital and the ratio of investment from internal financing of investment to personal income was .20, a crude measure of farm operators' average propensity to save and invest. In the same period, Americans as a whole saved only 6 percent of their personal income. Since 1972, personal incomes of farm and nonfarm persons have been nearly equal on the average. But if farmers to survive are forced to invest one-fifth of their personal income in the farm operation in the face of severe

cash-flow problems, does comparable personal income between the farm and non-farm sectors represent comparable levels of living? It may be contended that the accumulated investment in farming provides deferred income which can be used for retirement — but operators may realize only a portion of that buying power because they use some deferred income to establish their children in farming.

Corporate or other arrangements to separate farm ownership from farm operation could reduce the need for high mandatory savings-investment rates by farm operators but raises additional structural issues. An economic farming unit today providing full-time employment for a farm operator entails assets of approximately \$1 million and sales of \$125,000. Such a unit provides on the average about \$6,250 of management return (5 percent of sales), \$8,000 of labor return and \$5,750 of equity return if the operator has 20 percent equity in the unit for a total return of \$20,000 for the farm family, the median income of families in the U.S. The lower the equity, the larger must be the operation to provide \$20,000 of family income. A full renter who hires additional labor to expand operations above the \$125,000 sales size and with small equity return would need to expand sales by $(\$5,750/.05) = \$115,000$ or by 92 percent to earn \$20,000 from his labor and management alone. These figures are only illustrative, but indicate that maintenance of a family farm structure requires substantially larger farming units if farmland ownership is separated from farm operation and the family depends on farming alone to provide a level of income comparable to that of non-farmers.

In addition to possible sociological impacts of tenancy on farm families and rural communities, the impact of tenancy could also be reduced rates of investment. If a population of tenant farmers save at the same rate as the population as a whole, savings from farmers would be reduced by up to 70 percent. This figure represents an upper limit because complete tenancy is an unrealistic scenario and because the corporations that would replace many family farms would also have high savings and investment rates, plowing approximately 40-50 percent of earnings into the business if they behaved like the average U.S. corporation. Again, I submit we know too little about the impact on savings, investment, economic efficiency and rural communities of a departure from the traditional family farming structure toward a few large corporate farms producing most farm output and many small part-time farms accounting for most farms.

CROPLAND

The recent National Agricultural Lands study provides massive data on use of agricultural lands and on potential cropland not currently cropped. While data showing opportunities for adding to cropland may provide useful information for some purposes, it is important to note that the nation has and probably will continue to rely heavily on the market to allocate land between cropping and other uses. At issue is what prices

for farm products would be necessary to slow conversion of farmland to other uses and cause conversion of potential cropland to use for crops.

David Ralls, a graduate student in agricultural economics at Oklahoma State University, has related cropland to real farm prices as well as other variables in a variety of econometric specifications. The most notable outcome of his research to date is inability to reject the null hypothesis that cropland is unresponsive to real or nominal farm prices. Of course, this negative finding does not mean that the null hypothesis is true. Perhaps the specification is incomplete or the historic variation in prices and acreage is too narrow to provide reliable estimates. But I am puzzled over the value of "potential cropland" estimates to measure reserve production capacity when we know so little of the economic environment required to crop potential cropland. If cropland is as unresponsive to price as indicated to date, we need to direct greater attention to other sources of future output such as unconventional research and extension inputs and conventional capital inputs.

THE CHANGING ROLE OF AGRICULTURAL ECONOMISTS

The final topic is some dilemmas for agricultural economists in policy, marketing and management specialities.

First, consider the agricultural policy specialist. Until approximately 1970, the farming industry was economically distressed as measured by per capita personal income, poverty, and rates of return on resources. It was characterized by excess capacity and redundant labor that could not be supported by the market alone with satisfactory earnings. Policy economists often went along with measures to redistribute income to the farming sector, a stance which appealed to many in the farming community.

In the 1980's, the economic setting is quite different with commercial farmers expected to realize rates of return on resources, personal income and wealth at least on a par if not well in excess of those realized by nonfarm persons on the average. It is very difficult for policy economists nowadays to argue for farm policies that interfere with efficient market allocation to benefit farmers at the expense of society or which transfer income from nonfarmers to farmers. Popularity of the policy economist among farmers is not helped by his failure to support programs to redistribute income to farmers. The dilemma or challenge to the policy economist is to maintain his professional integrity without jeopardizing his own professional position or that of his colleagues, including the production scientists who are also vital to continuing productivity growth of the farming industry and the nation.

Outlook economists face problems similar to policy economists in that past success jeopardizes their mission. The hog and cattle cycles appear to be attenuated by predictions of a cycle turnaround and attendant prospects for better prices. With sufficient numbers of outlook economists providing such forecasts and enough producers taking them seriously, the result is

increased production and lower prices. The paradox is that the usefulness of outlook specialists is called into question by producers at the very time when the outlook information is most effective. The puzzle is how to provide effective outlook information that is not viewed as self-defeating in the minds of producers. One answer to both policy and outlook economists is to obtain broader support from consumers who benefit from economic information.

Dilemmas facing publicly supported farm management and marketing economists are also not easily resolved. Emphasis has traditionally been on serving the mid-size family farm, but such farms are declining in absolute and relative numbers as well as in share of farm output. The need is apparent to broaden the clientele. Should increasing attention be given to large farms which produce most of the output, are politically strategic, but can afford to pay the cost of obtaining sophisticated management and marketing information from private sources? Or should greater emphasis be placed on part-time small farmers who will eventually dominate farming in terms of numbers, who traditionally have not been easily reached by or supportive of agricultural research and extension but who have considerable room for efficiency gains? If the role of agricultural economists is to perform those services which the private sector is unable to perform, the latter group warrants more attention. But to do so will require considerable innovations both in research and extension, the latter in devising satisfactory delivery systems. Perhaps agricultural economists from the Northeast, who already have made considerable adjustments, have something to say to the rest of us on such issues.

SUMMARY AND CONCLUSIONS

Many unresolved issues confront the agricultural economist in the 1980's. Issues outlined herein include appropriate macroeconomic policy and its impact on farmers including interrelationships with other economies around the world.

Data indicate that demand has increased faster than real supply since 1950, but this dominance of excess demand is not apparent in farm prices. Several hypotheses were advanced to explain the anomaly but determination of precise contributions of each hypothesis awaits further study.

The behavior of farming investment in relation to instability and commodity programs raises several unresolved issues. Is per capita personal income of farm and nonfarm people a reasonable measure of level of living if farm families have no alternative to investing high proportions of their income in the farm to survive as farmers? Is unstable farm income useful to sustain high rates of investment by farm families?

The public is concerned about the capacity of the farming industry to respond to food needs at home and abroad in the 1980's. In part because of this concern, much research has focused on potential cropland. Yet we know very little about what economic inducements are required to utilize potential cropland. Estimates to date

provide little optimism that much additional land will be converted to crops with higher farm prices and it may be well to focus more attention on other sources of additional farm output such as production-oriented agricultural research and extension.

Finally, this paper raises issues concerning the future role of the agricultural economist. He continually needs not only to redefine problems but also his clientele and delivery systems. The issues deserve more attention than given herein.

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APPENDIX

The demand function at the farm level is conceptualized as

$$(1) \quad q_d = q_d(P \mid P_N, P_I, Y, N)$$

where q_d , quantity demanded of farm output per unit of time, is a function of prices received by farmers P . P_N is prices of substitutes and components of farm output, P_I is the general price level, Y is per capita nominal income and N is population. The schedule $q_d: P$ traces out the demand curve with demand shifter variables to the right of the vertical line in (1) held constant.

Prices and incomes in empirical as opposed to conceptual demand functions are generally expressed in deflated form

$$(2) \quad q_d = q_d(P/P_I \mid Y/P_I, N)$$

where P_N is dropped because it cannot be separated from the deflator, P_I . Per capita real income and population are the demand shifters.

The supply curve at the farm level is conceptualized as

$$(3) \quad q_s = q_s(P \mid P_P, P_I, T)$$

where q_s , quantity supplied of farm output per unit of time, is a function of prices received by farmers P , prices paid by farmers P_P , the general price level P_I , and technology or output per unit of production inputs T . The schedule $Q_S: P$ traces out the supply curve with other prices and T , the shifters, held constant.

Prices in empirical as opposed to conceptual functions are usually deflated so

$$(4) \quad Q_S = Q_S(P/P_I \mid T).$$

The real supply curve is shifted by productivity T . The high correlation between P_I and

P_P usually precludes inclusion of both variables in empirical time series supply equations. Input supply is assumed to be perfectly elastic and the elasticity of prices paid by farmers with respect to the general price level assumed to be unitary elasticity. In Tables 1 and 2, the ratio P/P_P is used as a measure of trends in real prices associated with shifts in demand and supply, but it is recognized that such procedure begs the question of inflation passthrough (e.g. from P_I to P_P , a supply shifter) examined by Tweeten (December, 1980a).

Total quantity of farm output demanded is the sum of the quantity demanded for domestic use q_d and the quantity demanded for export use q_e . Hence, the total change in demand and quantity Q per year t is

$$(5) \quad \frac{dQ}{dt} = \frac{dq_d}{dt} + \frac{dq_e}{dt}.$$

The domestic demand function for food and fiber at the farm level is specified as:

$$(6) \quad q_d = \alpha P^\beta Y^\gamma N$$

where α is a constant, P is deflated prices received by farmers, β is the price elasticity of demand, Y is real disposable income per capita, γ is the income elasticity of demand, and N is domestic population. The derivative with respect to t is

$$(7) \quad \frac{dq_d}{dt} = \alpha \beta P^{\beta-1} Y^\gamma N \frac{dP}{dt} + \alpha \gamma P^\beta Y^{\gamma-1} N \frac{dY}{dt} + \alpha P^\beta Y^\gamma \frac{dN}{dt}.$$

Multiplying equation (7) by $\frac{1}{q_d}$ or $\frac{1}{\alpha P^\beta Y^\gamma N}$ yields

$$(8) \quad \frac{dq_d}{q_d dt} = \beta \frac{dP}{P dt} + \gamma \frac{dY}{Y dt} + \frac{dN}{N dt}.$$

Taking equation (5), dividing by Q and inserting results from equation (8), the proportional change in total demand quantity Q is

$$(9) \quad \frac{dQ}{Qdt} = \left\{ \beta \frac{dP}{Pdt} + \gamma \frac{dY}{Ydt} + \frac{dN}{Ndt} \right\} \frac{q_{dt}}{Q_t} + \frac{dq_e}{q_e dt} \frac{q_{et}}{Q_t}$$

where

$\frac{dP}{Pdt}$ = proportional change in prices received by farmers,

$\frac{dY}{Ydt}$ = proportional change in real disposable personal income per capita

$\frac{dN}{Ndt}$ = proportional change in population,

$\frac{q_{dt}}{Q_t}$ = proportion of output used domestically,

$\frac{dq_e}{q_e dt}$ = proportional change in export quantity,

$\frac{q_{et}}{Q_t}$ = proportion of output exported.

Since we are focusing on real demand shifts and not changes in quantity demanded along the demand curve, price parameters can be omitted. Although export demand is affected by real domestic price, no easy adjustment isolates the price component from the shift component of export demand. Because exports increased slowly in the 1950's and 1960's and because the ratio of prices reviewed by farmers to the Consumer Price Index was only 4 percent greater in 1979 than in 1960, failure to remove the domestic price component from the export shift is expected to cause only minor bias. The formula for indicating the magnitude of real demand shifts is:

$$(10) \quad \frac{dq}{Qdt} = \left\{ \gamma \frac{dY}{Ydt} + \frac{dN}{Ndt} \right\} \left(\frac{q_{dt}}{Q_t} \right) + \frac{dq_e}{q_e dt} \left(\frac{q_{et}}{Q_t} \right)$$

Proportional changes in equation (10) are converted to percentages by multiplying by 100 to obtain results in text Tables 1 and 2.