MASTER

MEMORANDUM

TO: Michael J. McCabe

cc: Jim Smith
George Pomeroy

FROM: David P. Ross

DATE: November 4, 1980

SUBJECT: Methodology for Inducing Cyclicalities into ORNL Based Shipments Projections

In estimating regulatory impacts on appliance manufacturers, it is necessary to utilize projections of appliance shipments. Present shipment projections are derived from the ORNL model and are presented below:

Appliance Type	Base Period (ADL, 1978)	1981		1986	
		Units	Percent Change	Units	Percent Change
Refrigerators	6581.7	6923.9	5.2	7878.3	19.7
Freezers	1502.0	1548.6	3.1	1852.0	23.3
Ranges	6340.5	6632.2	4.6	7164.8	13.0
Water heaters	5600.0	5930.4	5.9	6518.4	16.4
RAC	4059.7	4538.7	11.8	5403.5	33.1
CAC	1531.3	1647.7	7.6	1868.2	22.0
Furnaces	2387.5	2483.0	4.0	2695.5	12.9
Dryers	3519.9	3681.8	4.6	3991.6	13.4

Because the ORNL model is a long-run model, the projected appliance shipments are also long-run in nature and consequently exhibit no cyclical behavior. The following presents a methodology for projecting appliance shipments which incorporates cyclical variation in conjunction with the long-run trends provided by the ORNL model.

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For analytical purposes, it is convenient to separate the overall market for appliances into two segments: (1) Replacement Demand, and (2) New Demand. These two groups respectively represent consumers replacing appliances as they wear out or purchasing previously unowned appliances, and institutional demand for new appliances. Each group is assumed to have demand functions for individual appliances that are driven by different factors. In particular, replacement demand is assumed to be responsive to changes in appliance prices and to changes in consumer disposable income. New demand, on the other hand, is assumed to be principally determined by new housing starts. The demand functions posited for each group are then as follows:

Replacement Demand

$$Q_1 = aP^\alpha Y^\beta X^\gamma$$

where

Q_1 = quantity demanded (shipments)

P = appliance price

Y = consumer income

X = other factors

New Demand

$$Q_2 = bHS^\delta X^\gamma$$

where

Q_2 = quantity demanded (shipments)

HS = housing starts

X = other factors

Taking total differentials and dividing each equation by the appropriate quantity (i.e., Q_1 or Q_2) yields:

$$\frac{dQ_1}{Q_1} = \alpha \frac{dP}{P} + \beta \frac{dY}{Y} + \gamma \frac{dX}{X}$$

and

$$\frac{dQ_2}{Q_2} = \delta \frac{dHS}{HS} + \gamma \frac{dX}{X}$$

or

$$\% \Delta Q_1 = \alpha \% \Delta P + \beta \% \Delta Y + \gamma \% \Delta X$$

and

$$\% \Delta Q_2 = \delta \% \Delta HS + \gamma \% \Delta X$$

where

α = price elasticity of demand

β = income elasticity of demand

γ = other factors "elasticity" of demand

δ = housing starts "elasticity" of demand

Thus, the year-to-year percentage change in replacement demand (new demand) shipments can be estimated by employing appropriate elasticity estimates and projections of year-to-year percent changes in income, appliance prices, and other factors (housing starts and other factors).

In implementing the methodology, several assumptions are necessary. First, the effects of "other factors" are assumed to be long-run in nature and thus appropriately represented by the long-run trends derived from the ORNL model. Thus, the coefficient on this term, γ , is assumed to be one (1.0). These baseline trends are presented below on an annualized basis for two periods: pre-1981 and post-1981.

<u>Appliance</u> (1)	<u>Annual Percent Change in Shipments</u>	
	<u>Pre-1981</u>	<u>Post-1981</u>
Gas Range	1.51	2.47
Electric Range	1.51	2.47
Electric Dryer	1.51	2.55
Refrigerator-freezer	1.70	3.66
Home-freezer	1.02	4.28
RAC	3.79	5.89
Warm Air Oil Furnace	1.32	2.46
Warm Air Gas Furnace	1.32	2.46
Warm Air Electric Furnace	1.32	2.46
Electric Water Heater	1.93	3.08
Gas Water Heater	1.93	3.08
CAC	2.47	4.06

(1) Fuel type not differentiated in ORNL data, assumed equal for each fuel type.

Second, cyclicalities in appliance shipments is assumed to be induced by year-to-year deviations from the respective overall trends in appliance prices, consumer disposable income, and new housing starts. Data to compute these deviations are readily available in "Forecasts of Appliance Prices to the Year 2000," prepared by Data Resources, Inc. The computation of annual percent changes in the real prices of appliances was accomplished by utilizing the following formula:

$$(1 + n) = (1 + i) (1 + r)$$

where

n = nominal price change rate

i = inflation rate

r = real price change rate

and appliance price and overall CPI projections provided by DRI. Third, coefficients for price and income elasticities are appliance specific and are taken from the Arthur Young study "Economic Impact of Appliance Efficiency Targets and Standards", July 1979. Elasticities utilized are illustrated below.

<u>Appliance</u>	<u>Price Elasticity</u>	<u>Income Elasticity</u>
Gas range	-1.275	0.0 ⁽¹⁾
Electric range	-1.032	1.254
Electric Dryer	-2.879	3.117
Refrigerator-Freezer	-1.279	2.321
Home Freezer	-3.038	.963
Room Air Conditioner	-2.973	1.359
Warm Air Oil Furnace	-2.087 ⁽²⁾	0.0 ⁽²⁾
Warm Air Gas Furnace	-2.087	0.0 ⁽¹⁾
Warm Air Electric Furnace	-2.087 ⁽²⁾	0.0 ⁽²⁾
Electric Water Heater	0.0 ⁽¹⁾	0.0 ⁽¹⁾
Gas Water Heater	0.0 ⁽¹⁾	0.0 ⁽¹⁾
Central Air Conditioner	0.0 ⁽¹⁾	0.0 ⁽¹⁾

(1) No value reported in Young study, Zero assumed

(2) Coefficient assumed equal to that for gas furnace

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Finally, the coefficient on housing starts, δ , is also assumed to be one (1.0).

In computing the overall annual percent change in appliance shipments, it was assumed the replacement demand and new demand represented equal market shares. Therefore, the total percent change in shipments is given by the following formula:

$$\% \Delta Q = 0.5 * \% \Delta Q_1 + 0.5 * \% \Delta Q_2$$

Under the assumptions described above, annual percent changes in appliance shipments for each of twelve appliances were calculated. The results of these computations are presented in the following table. Additional runs with revised or additional elasticity estimates and/or other parameters can easily be accommodated.

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PROJECTED ANNUAL PERCENT CHANGES IN APPLIANCE SHIPMENTS

YEAR	GR	ER	ED	RF	HF	RAC	WADF	WAGF	WAEF	EWB	GWB	CAC
1980	1.88	0.70	-3.16	-0.71	-1.60	2.40	1.89	0.07	5.29	1.93	1.93	2.47
1981	12.31	12.47	8.59	11.73	9.59	16.25	11.89	11.03	12.11	12.97	12.97	13.50
1982	7.25	7.51	7.63	8.14	11.21	12.76	6.39	6.20	7.97	7.87	7.87	8.85
1983	0.66	1.58	3.63	3.37	5.46	6.10	0.75	0.76	-0.56	1.27	1.27	2.25
1984	0.33	0.44	1.62	2.13	4.08	5.37	0.38	0.29	1.29	1.47	1.47	2.44
1985	10.23	9.66	8.92	12.19	13.70	15.37	8.50	9.48	11.26	10.36	10.36	11.34
1986	9.32	9.47	9.03	11.27	11.72	15.62	7.80	9.46	9.39	9.56	9.56	10.54
1987	1.60	4.02	6.81	5.66	4.57	8.22	1.01	1.62	0.77	1.92	1.92	2.90
1988	-4.73	-2.16	-3.14	-1.99	-2.97	0.41	-3.10	-3.86	-2.66	-2.88	-2.88	-1.90
1989	-2.37	-1.17	-0.27	0.30	-0.13	1.38	-1.20	-1.37	-0.95	-0.89	-0.89	0.09
1990	4.62	4.17	2.55	5.71	6.38	8.45	4.45	4.87	4.80	4.87	4.87	5.85
1991	1.36	1.10	1.55	2.86	3.13	4.01	1.06	1.47	0.72	1.67	1.67	2.65
1992	-3.54	-3.28	-4.23	-2.97	-2.68	-1.97	-2.70	-3.46	-4.59	-2.58	-2.58	-1.60
1993	-1.25	-1.34	-1.38	0.08	0.49	1.00	-0.06	-0.61	-1.17	-0.24	-0.24	0.74
1994	1.75	0.71	-0.13	2.14	3.12	4.11	1.95	1.98	1.43	2.17	2.17	3.15
1995	1.41	0.80	1.77	2.61	2.77	3.91	1.26	1.49	0.45	1.77	1.77	2.75
1996	1.13	0.28	1.26	0.97	1.70	3.03	0.76	0.89	-0.06	1.37	1.37	2.34
1997	1.66	1.07	2.58	2.14	2.93	3.26	1.60	1.83	0.59	2.02	2.02	3.00
1998	1.54	0.61	1.80	1.56	2.55	2.92	1.70	1.83	0.59	2.02	2.02	3.00
1999	1.89	1.27	2.80	2.43	3.14	3.04	2.05	2.18	0.85	2.37	2.37	3.34
2000	2.83	1.86	2.76	2.91	3.90	3.70	2.95	3.09	1.85	3.37	3.37	4.35