THE EFFECTIVENESS OF PRICE SUPPORT POLICY—SOME EVIDENCE FOR U.S. CORN ACREAGE RESPONSE

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A method is reported for measuring supply response in an environment in which Government price supports and market conditions both influence producers' decisions. This method is used to analyze U.S. corn acreage data.

Keywords:

Corn acreage response
Producer price expectations
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INTRODUCTION

The decade of the seventies has brought a new economic environment for farmers' production decisions. Risk, increasing costs, and the influence of Government price support policy *vis a vis* market prices are important characteristics. Conceptual frameworks have been presented for assessing producers' reactions. Moreover, methods for measuring producers' responses to risk and cost inflation have been developed, confirming the significance of these characteristics.[1]

The role of Government support prices in this new environment has received less attention. In this article, I present a method of measuring price expectation for analyzing supply response when the influence of price support and market phenomena varies with market conditions. Then, I present estimates of U.S. corn acreage response using this expected price equation.

PRODUCER PRICE EXPECTATIONS IN THE CASE OF PRICE SUPPORTS: A REVIEW OF SOME CONCEPTS

In analysis of producer behavior under conditions of uncertainty, an accepted view starts with the assumption that producers perceive a probability distribution on price outcomes. Production then depends on the characteristics of this distribution. In all cases, output and expected price are positively related. And, unless producers are indifferent to risk, supply will also depend on the variance of the perceived distribution (*2*, pp. 439-488). In line with the findings of other authors, this study will allow for producers' reactions to price risk (*5*, *8*). However, my central concern is to investigate the role of Government support and market phenomena in forming producer price expectations.

The existence of price supports suggests a restriction on the probability distribution. Just points out that price supports define a risk floor below which the price paid to farmers cannot fall (*4*). Thus, a probability density function, $f(P)$, would have the following properties:

$$\int_{PS}^{\infty} f(P)\,dP = 1 \text{ and } PE = \int_{PS}^{\infty} Pf(P)\,dP.$$

Other literature contains the assertion that the position of density function, $f(P)$, depends on past market phenomena.[2] To incorporate market conditions into the discussion, consider strong and weak markets. When the market has been weak, $f(P)$ shifts towards the support price. Expected price is very near the support price, and, hence, output should depend primarily on support prices. However, $f(P)$ shifts away from the risk floor when market prices have substantially exceeded support price. Under these circumstances, market price should have the predominant effect on output decisions (fig. 1).

METHODS FOR MEASURING PRODUCER RESPONSE TO SUPPORT AND MARKET PRICES

An appropriate econometric model of producer response to price would assign the dominant allocative role to support prices under weak market conditions and to market prices under strong market conditions. Some previous specifications do satisfy this criterion with the assumption that producer response to price is determined exclusively by past market price when prices are buoyant or support prices when the market is weak. However, it is often assumed that the response to support prices is constant, regardless of

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[1] See (*4*) for a review of conceptual frameworks appropriate for incorporating risk, cost inflation, and support policy. Just (*5*) and Ryan (*8*) provide evidence that risk influences farmers' production decisions. Evans (*1*) shows that input cost increases have an effect on U.S. cotton acreage.

Note: Italicized numbers in parentheses refer to items in References at the end of this article.

[2] See (*4*, p. 3) for a summary.

market conditions (3). Policy analysis would be enhanced if one allows for the possibility that support prices affect producers' decisions even under moderate and strong market conditions. The method that follows features market price elasticities that strengthen with market surges and support price elasticities that increase as markets weaken.

An estimable production response model requires the statement of a supply relation and an expectations formation mechanism. To illustrate, consider a linear relation between supply (S_t) and expected price (PE_t):

$$S_t = \alpha + \psi PE_t + \epsilon_t \tag{1}$$

Supply shifters important in empirical analysis, such as expected prices for competitive crops, risk, costs, and policy variables, are allowed for in the constant (α). The expectations formation relation is a rather complicated function of current-year support price (PS_t) and previous crop year market price (PM_{t-1}):

$$PE_t = PS_t + \gamma \left[(D_t + 1) \ln (D_t + 1) - D_t \right] \tag{2}$$

where

$$D_t = PM_{t-1} - PS_t$$

The advantage of this expected price formulation is that the response of expected price to changes in market or support price can be expressed as a simple function of the difference between market and support price (D_t):[3]

$$\frac{\partial PE_t}{\partial PM_{t-1}} = \beta_t (D_t) \tag{3a}$$

and

$$\frac{\partial PE_t}{\partial PS_t} = 1 - \beta (D_t) \tag{3b}$$

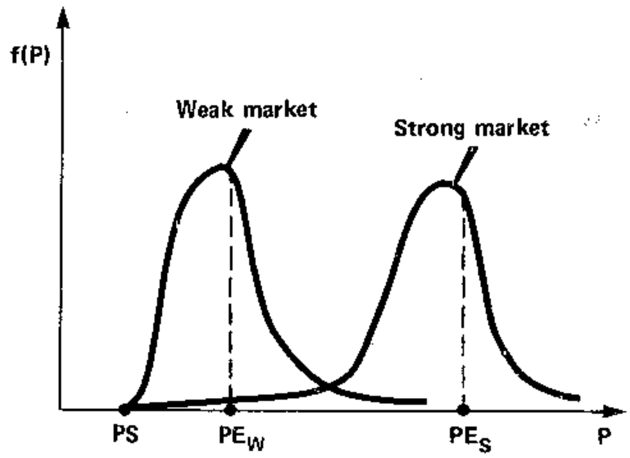
where

$$\beta (D_t) = \gamma \ln(D_t + 1)$$

For strategic assignments of the parameter γ (that is, $\gamma > 0$ and not too large), $0 \leqslant \beta (D_t) \leqslant 1$. Under these circumstances, supply response to market and support prices can be expressed as the supply response parameter (ψ) and a multiplier $\beta(D_t)$ or $(1 - \beta(D_t))$ which varies with market conditions:

[3] In fact, the expected price equation (2) was obtained by specifying that expected price was an unknown function of PS_t and PM_{t-1} which satisfied (3a) and (3b). The procedure for finding a function given partial derivatives is described by Taylor (9, p. 437).

FIGURE 1
Probability Distributions and Expected Prices for Strong and Weak Market Conditions



$$\frac{\partial S_t}{\partial PM_{t-1}} = \psi \beta (D_t) \tag{4a}$$

$$\frac{\partial S_t}{\partial PS_t} = \psi \left[1 - \beta (D_t) \right] \tag{4b}$$

The analogous elasticities for support and market prices are:

$$^{e}S_t \cdot PM_{t-1} = \frac{PM_{t-1}}{S_t} \psi \beta (D_t) \tag{5a}$$

$$^{e}S_t \cdot PS_t = \frac{PS_t}{S_t} \psi \left[1 - \beta (D_t) \right] \tag{5b}$$

An examination of the multiplier, $\beta (D_t) = \gamma \ln(D_t + 1)$, verifies that supply elasticities can adjust appropriately with market conditions. Figure 2 illustrates this function when the parameter, γ, assumes positive values. $\beta (D_t)$ is zero, for example, when the market price falls to the risk floor ($D_t = 0$)—the corresponding elasticities for market and support prices are zero and one, respectively. As market conditions strengthen, $\beta (D_t)$ increases, so the market price elasticity increases and the support price elasticity decreases.

There are some limitations on this approximation to producer behavior. Under the strongest market conditions, it is plausible that producers base their decisions solely on market prices ($\beta = 1$) and ignore support policy. However, it would be unreasonable to suggest that negative weight is given to support policy ($\beta > 1$). A point on the horizontal axis of figure 2 (D_{max}) shows the limit of this approximation. Given an assignment for

γ, price differences beyond this point suggest that farmers place a negative weight on support policy and more than complete weight on market phenomena.

METHODOLOGY

The central empirical issue is the extent of producer adjustment between support and market signals as market conditions vary. In the algebraic model, this issue reduces to estimating the value of the parameter γ in equation (2). When the supply and price expectation relations (equations (1) and (2)) are combined, however, the resulting relation between observable variables is nonlinear in the parameters ψ and γ:

$$S_t = a + \psi \left[PS_t + \gamma (D_t + 1) \ln (D_t + 1) - D_t\right] \quad (6)$$

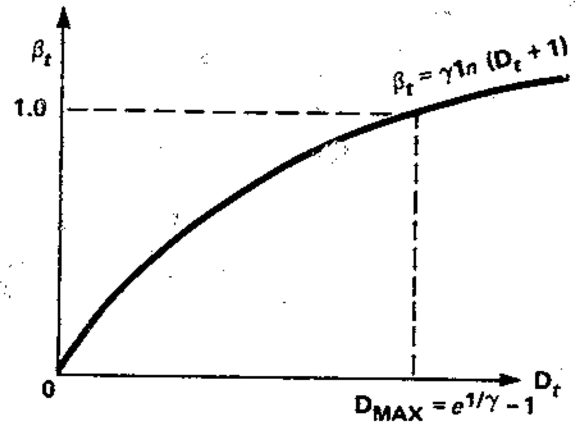
Least squares estimation of equation (6) would produce the best linear unbiased estimates of a, ψ, and $\psi\gamma$ with the usual assumptions about the residuals. In view of the emphasis on obtaining estimates of the structural parameter γ, however, a nonlinear maximum likelihood technique is superior, as this procedure would yield consistent, efficient estimates of a, ψ, and γ (7, p. 481). Parameter estimates are obtained with a program that minimizes the sum of squared residuals for a nonlinear regression equation—the objective function for this problem is the same as maximum likelihood estimation with the assumption of a normal disturbance term.

ESTIMATES OF U.S. CORN ACREAGE RESPONSE

Previous investigation of U.S. corn acreage response was designed to analyze the policy-dominated decades of the fifties and sixties, although later modification accounted for producer response to the strong market conditions of the mid-seventies. The early studies featured effective price support and diversion payment variables for measuring the composite effects of Government corn policies but producer response to market prices was not included. Important crop substitutions were also identified—sorghum and corn competed for land use during the fifties and a corn-soybean substitution has been significant through the last three decades. More recent estimates accounted for strong market prices with a spliced supply inducing price. That is, producers were assumed to respond to (1) effective support price prior to 1972 and (2) lagged market price afterwards.[4]

[4] For a summary of previous corn acreage response studies, see (3, pp. 11-29).

FIGURE 2
Price Adjustment Weight (β_t) Versus the Difference Between Support and Market Prices (D_t)



Estimates presented here verify the price expectation formulation (equation (6)) and extend the analysis to include other elements that have been important in the seventies. However, these specifications retain the basic Houck-Ryan formulation of policy variables and land use competition. Indeed, the substitution with soybeans was considered important enough to warrant the inclusion of an expected soybean price, where expected price is defined in (equation 6). Other explanations of acreage variation that have received attention recently are included in the corn acreage equation. Price risk is measured along the lines suggested by Ryan and cost increases are accounted for by deflating expected corn and soybean prices with variable cost measures.

Table 1 contains two specifications of the basic acreage response model. Both of these equations include expected prices relative to costs of production for corn and soybeans (PEC_t/CAC_t and PES/CAS_t)—the expected price variables are based on estimated values of adjustment parameters (γ_c and γ_s) for corn and soybeans. Both relations also feature corn diversion policy variables (DPC and DV66), a risk term ($RISK_t$), and a variable which measures substitution in the fifties between corn and grain sorghum ($ASGPM_t$). The difference between table equations 1.1 and 1.2 is that the latter equation also contains a lagged dependent variable; this specification is included as a test of the hypothesis that farmers cannot make complete adjustments when large price changes occur.

The statistical properties of both equations are acceptable. The R^2 statistic exceeds 97 percent in both cases, indicating that either set of explanatory variables provides a good explanation of historical corn acreage variation. Moreover, standard errors are small relative to estimated coefficient magnitudes, suggesting that

Table 1—Nonlinear least squares estimates with corn planted acreage (ACP_t) as dependent variable, 1954-77

(Dependent variable mean: 72,993.5)

Equation	Constant	$DV66_t$	$ASGPM_t$	DPC_t	$RISK_t$	ACP_{t-1}	$\frac{PEC_t}{CAC_t}$	γ_c	$\frac{PES_t}{CAS_t}$	γ_s	R^2	$\overline{S}$	Sum of squared errors
(1.1):													
Coefficient	80,475.65	4,838.92	−0.40794	−64.079.79	−3,078.416		687,277.28	0.78356	−63,713.36	0.55584	.9746	1,288.46	28,222,159.0
Standard error	5,839.45	888.69	.16866	7,574.67	1.975.54		191,736.76	0.38980	38,668.88	0.40251			
Elasticity at mean				−0.091			0.159		−0.080				
(1.2):													
Coefficient	75,472.62	4,717.30	−0.432111	−61,362.73	−2,736.37	0.032449	768,859.05	0.888505	−51,753.99	0.59775	.9764	1,279.99	26,214,080.0
Standard error	7,702.00	886.97	.16808	7,830.16	1,968.31	.03657	206,094.67	.47573	42,473.42	0.56276			
Elasticity at mean				−0.087			0.178		−0.065				

Definitions of variables:

ACP_t: U.S. planted corn acreage (thousands)

$$DV66_t = \begin{cases} 1, & 1966\text{-}72 \\ 0, & \text{otherwise} \end{cases}$$

$$ASGPM_t = \begin{cases} ASGP_t, & 1954\text{-}66 \\ \overline{ASGP}, & \text{for previous period, 1961 to date} \end{cases}$$

$ASGP_t$: U.S. acreage in sorghum grains (thousands)
DPC_t: Corn, effective diversion payment rate (dollars/bushel)
PFC_t: Corn, effective price support (ditto)
PMC_t: Corn, U.S. season average price received by farmers (ditto)

CAC_t: Corn, variable costs per acre (dollars per acre)
PSS_t: Soybeans, effective price support (loan rate) (dollars per bushel)
PMS_t: Soybeans, U.S. season average price received by farmers (ditto)
CAS_t: Soybeans, variable costs per acre (dollars per acre)

$$RISK_t = \frac{(PMC_{t-1} - MAC_t)^2}{MAC_t}, \text{ where } MAC_t = 1/3\ (PMC_{t-2} + PMC_{t-3} + PMC_{t-4})$$

$$PEC_t = PFC_t + \gamma_c \left[(DC_t + 1)\ 1n\ (DC_t + 1) - DC_t\right], \text{ where } DC_t = PMC_{t-1} - PFC_t$$

$$PES_t = PSS_t + \gamma_s \left[(DS_t + 1)\ 1n\ (DS_t + 1) - DS_t\right], \text{ where } DS_t = PMS_{t-1} - PSS_t$$

implications about structure could be drawn from the estimates.

The parameter estimates are generally similar to those obtained in earlier studies, but there are some exceptions. The measured effects of diversion policy and sorghum substitution are similar to the ones reported earlier. The acreage response to a change in expected corn price is also in accordance with other studies—elasticity estimates are between 0.1 and 0.2. The response to changes in expected soybean price, however, is smaller than previously. The elasticity estimates in table 1, 0.07 to 0.08, are roughly half the magnitude of earlier estimates. The reduced effect on soybean price could be attributed to the risk term, which explains a significant portion of recent corn acreage variation. In fact, the risk estimate (equation 1.2) suggests that corn acreage expansions between 1972 and 1975 were above 3.0 million acres less than if there had been no increases in risk.

In short, either equation (1.1 or 1.2) adequately explains historical variation. However, (1.2) is probably more accurate, since it contains the lagged variable, which is statistically significant.

CORN PRODUCERS' RESPONSE TO SUPPORT AND MARKET PRICES

As shown, the parameter γ determines the extent of producer adjustment between support and market price. That is, γ-estimates determine the magnitude of the adjustment weight (β) for given market conditions. In turn, β determines support and market price elasticities. Estimates of the adjustment between Government and market prices for corn and soybeans are presented below.

Corn and soybean adjustment functions are illustrated in figures 3 and 4, wherein β estimates are plotted against the difference between market and support prices (D). Specific values of D are also indicated on the horizontal axes: (1) mean values for a period of high support and moderate market prices (1969-72), (2) mean values for a period of strong market and low support prices (1973-76) and (3) the maximum difference between support and market prices. During the early period, market prices had a moderate effect—β values were around 0.25 for both commodities. In contrast, both β values were near one at the height of the seventies' price explosion. However, even at average values from the high price period, support prices affected acreage response moderately, a tendency more pronounced for corn; only 60 percent of the weight can be assigned to market price changes.

Table 2 indicates the extent of corn producers' response to support and market prices as market conditions vary. Corn and soybean price elasticities are computed for the three types of market conditions indicated in figures 3 and 4. The corn elasticities suggest that support and market prices both retain an allocative role under strong and weak market conditions. The ratio of support to market price elasticities is about 2:1 for weak markets and 1:3 for strong markets. The market elasticity dominates only under the strongest market conditions. The soybean response estimate suggests a more complete adjustment between support and market signals. The support/market ratio is around 5:1 for weak markets and 1:7 for strong markets. Moreover, support price had virtually *no* effect when soybean prices were strongest.

Table 2—Corn acreage support and market price elasticities

Market conditions \ Price	Corn		Soybeans	
	Support price	Market price	Support price	Market price
Weak[1]	0.13	0.06	0.05	0.01
Strong[2]	.06	.18	.01	.07
Strongest[3]	.02	.29	0	.10

[1] Based on mean values of data from 1969-72. [2] Based on mean values of data from 1973-76. [3] Based on data for the year when the difference between market and support price was largest—1975 for corn and 1977 for soybeans.

CONCLUSIONS

The estimates presented support the hypothesis that support price changes dominate under weak market conditions, while market prices prevail during the strongest market conditions. Moreover, corn support price influences farmers' decisions when moderate or strong market conditions prevail. Hence, support policy analysis which does not account for this assymetry could err in predicting the magnitude of farmers' acreage response.

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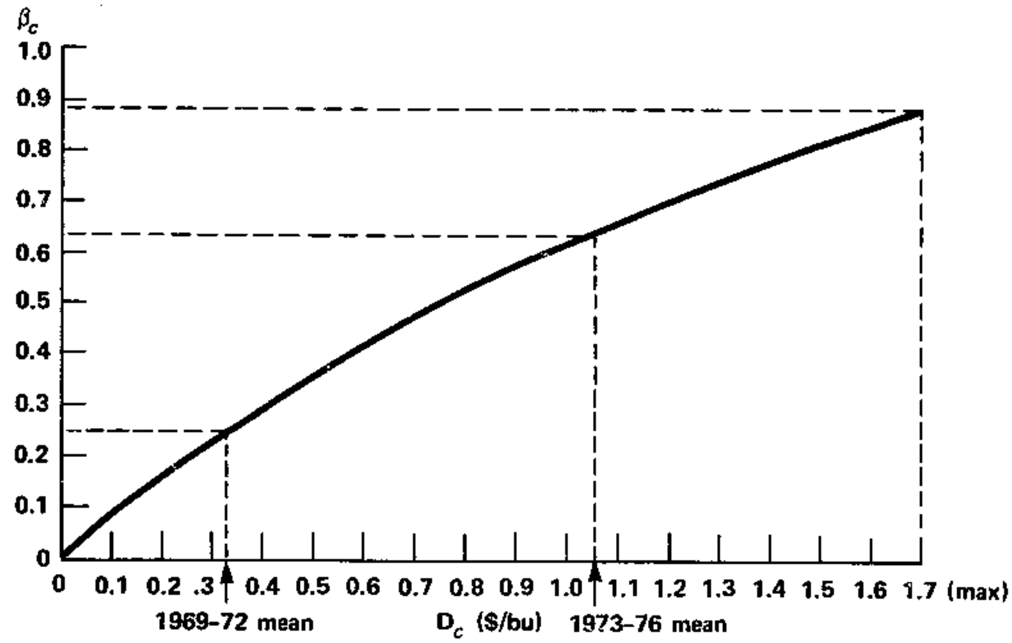
FIGURE 3

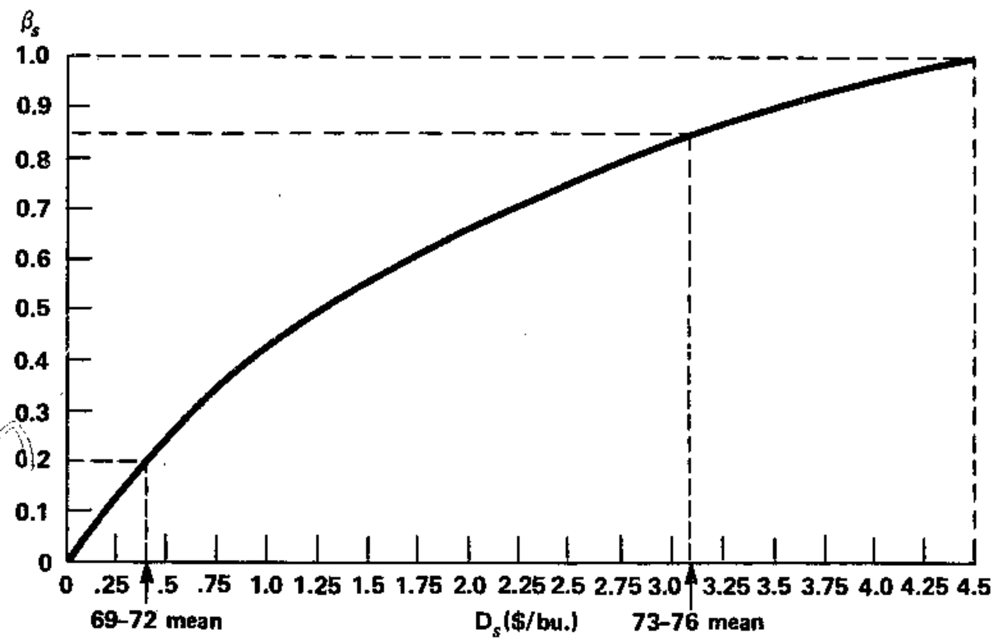
Corn: Market Price Adjustment Weight (β_c) Versus Difference Between Market and Support Price (D_c)



Note: $\beta_c = 0.888505\ 1n(DC_t + 1)$ $\beta_c = 1.0$ *when* D_c *= \$2.08/bu.*

FIGURE 4

Soybeans: Market Price Adjustment Weight (β_s) Versus Difference Between Market and Support Price (D_s)



Note: $\beta_s = 0.59775\ 1n(D_{s_t} + 1)$ · $\beta_s = 1.0$ *when* D_s *= \$4.33/bu.*

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APPENDIX

The appendix table contains the data for estimating corn acreage response. Much of this information is available through standard USDA sources. However, the origin of some data, particularly on cost and corn policy, requires elaboration.

The series for effective price support and diversion payments for corn were constructed by Houck and others in an analysis of Government commodity policies for the fifties and sixties. The data are extended here for the years covered by the Agricultural Adjustment Act of 1973. This law institutionalized target prices to support corn farmers' returns with direct cash payments—previously, producer returns had been supported solely through the Commodity Credit Corporation loan program. Target prices have generally exceeded loan rates but target price protection has been limited to a percentage of historical base acreages. Thus, corn effective support price for 1973-77 is a weighted average of target price and loan rate—the averaging weight is given by the percentage of planted acreage eligible for target price protection.[1] The 1973 act also extended the authority to initiate setaside programs. However, supplies were short through the 1977 crop year, so this provision was not invoked. Hence, no diversion payments were made in this period.

While commodity cost data are readily available for the inflationary period of the mid-seventies, information from the fifties and sixties requires aggregation of more basic data. Corn and soybean variable cost estimates for recent years (after 1973) are taken from USDA's Cost of Production surveys. Costs in earlier years are measured with a price index of major variable cost items (fertilizer, fuel, and seed) for corn and soybeans.[2] The index was converted to cost per acre units with the common year of data (1974) for costs of production and the price index.

[1] No target price program has been initiated for soybeans. Producer prices are still supported exclusively through the CCC loan program.

[2] Robert Hoffman (Treasury Department, Office of Raw Materials) graciously provided this information.

Appendix table—Data for corn acreage equation

Year	ACP_t	DPC_t	PFC_t	PSS_t	PMC_{t-1}	PMS_{t-1}	CAC_t	CAS_t	$DV66_t$	$RISK_t$
1954	82,185	0	1.30	2.22	1.48	2.72	58.92	27.31	0	0.005
1955	80,932	0	1.33	2.04	1.43	2.46	56.06	26.25	0	.010
1956	77,828	0	1.11	2.15	1.35	2.22	56.91	25.20	0	.011
1957	73,180	.043	.96	2.09	1.29	2.18	56.27	25.40	0	.012
1958	73,351	.052	.86	2.09	1.11	2.07	56.45	24.83	0	.045
1959	82,742	0	1.12	1.85	1.12	2.00	56.40	24.56	0	.014
1960	81,425	0	1.06	1.85	1.05	1.96	55.87	24.56	0	.013
1961	65,919	.192	.84	2.30	1.00	2.13	56.05	26.33	0	.008
1962	65,017	.192	.84	2.25	1.10	2.28	55.49	25.28	0	.002
1963	68,771	.112	.88	2.25	1.12	2.34	55.39	25.87	0	.005
1964	65,823	.180	.81	2.25	1.11	2.51	55.27	26.54	0	.001
1965	65,171	.180	.81	2.25	1.17	2.62	54.82	27.02	0	.003
1966	66,347	.248	.65	2.50	1.16	2.54	55.18	27.24	1	.001
1967	71,156	.150	.84	2.50	1.24	2.75	54.89	27.56	1	.008
1968	65,126	.241	.68	2.50	1.03	2.49	54.22	27.30	1	.022
1969	64,264	.241	.68	2.25	1.08	2.43	52.11	27.81	1	.004
1970	66,849	.231	.68	2.25	1.15	2.35	53.00	27.80	1	.001
1971	74,055	.160	1.05	2.25	1.33	2.85	57.78	30.77	1	.054
1972	66,972	.260	.89	2.25	1.08	3.03	60.75	32.01	1	.010
1973	71,900	.080	.83	2.25	1.57	4.37	63.51	41.02	0	.124
1974	77,800	0	1.32	2.25	2.55	5.68	88.43	46.34	0	1.128
1975	78,170	0	1.32	2.25	3.03	6.64	91.24	47.54	0	1.131
1976	84,120	0	1.56	2.50	2.54	4.92	86.39	46.98	0	.068
1977	82,740	0	2.00	3.50	2.20	7.32	89.25	48.85	0	.055