LABOR FORCE PARTICIPATION, WAGE RATES, AND MONEY ILLUSION

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I. INTRODUCTION

In view of the numerous studies of labor force participation in the past few years, it is surprising that so little attention has been given to the question of the effect of wage rates on participation rates over time. The results of the cross section studies of Mincer [4] and Cain [1] indicate that substitution effects dominate income effects for married women, which means that wage rates have a net positive effect on the labor force participation of this group. One would expect that this effect might appear in time series data as well, but most time series studies have not considered this possibility.[1] Wage rates may also affect the labor force participation of groups other than married women, and in general it is of interest to see what kinds of wage rate effects can be picked up using time series data.

There are two main problems that must be considered when analysing the effect of wage rates on participation rates over time: the choice of

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[1] See, for example, Tella [7] and Dernburg and Strand [2]. Officer and Andersen [5], using Canadian time series data, do report that a wage rate variable was tried in their equations, but that per capita income gave better results. Per capita income is interpreted by them as measuring "standard of living" effects (p. 283).

the appropriate wage rate variable and the specification of the appropriate lag distribution of wage rates on participation rates. It will be seen in Section II that these two problems are closely related; both concern the question of whether labor force participants respond more to the money wage or the real wage in the short run and thus whether there is any element of money illusion in the short run. It will also be seen from the work in Section II that it is possible to estimate the degree of money illusion on the part of labor force participants. In Section III these estimates are made for sixteen age-sex groups using quarterly U.S. time series data for the 1956I - 1970II period. The results in Section III indicate both the degree to which participation rates respond to wage rates over time and how much of this response is due to money illusion. Also, because of the inclusion of a time trend in each of the equations below, the results indicate how much of the increase or decrease in the participation rate of each age-sex group over time must be attributed to unexplained trend factors.

II. THE EFFECT OF WAGE RATES ON PARTICIPATION RATES

The Case of No Money Illusion

Whether wage rates have a positive or a negative effect on participation rates depends on whether the substitution effect or the income effect is dominant. If the substitution effect is dominant, as it appears to be for married women, then wage rates will have a net positive effect on participation rates. If the income effect is dominant, as it may be in the long run for primary workers, then wage rates will have a net negative effect on participation rates. *A priori* one cannot say which effect will dominate, although Mincer's discussion of the participation rates of married women indicates that the substitution effect is likely to dominate for this group. In general, however, it is an empirical question whether wage rates have a net positive or negative effect on participation rates.

Since people are likely to differ in the timing of their response to changing wage rates, it seems likely that group participation rates will be a function of a distributed lag of past wage rates. In addition, the behavioral response of a single individual may be such that he can be considered to be responding to a distributed lag of past wage rates. Two types of distributed lags were considered in this study. Both are depicted in Figure 1. The first is a quadratic lag distribution, which is constrained to be zero at the beginning and end of the distribution, and the second is a truncated Pascal distribution. The first distribution can be estimated by the Almon technique, with the distribution constrained to be zero at the two end points. The distribution is thus a function of only one parameter and can be estimated quite easily. The second distribution is a function of three parameters, and it can be estimated in the manner described in the Appendix.

Previous time series studies have indicated that participation rates are a function of the tightness of the labor market, as measured by the unemployment or employment rate, and this effect was taken into account in this study as well. Let LF_i denote the labor force of group i, POP_i the population of group i, M/POP the aggregate employment-population ratio, and WR the real wage rate. Then in the absence of money illusion, the equation explaining the labor force participation of group i is taken to be:

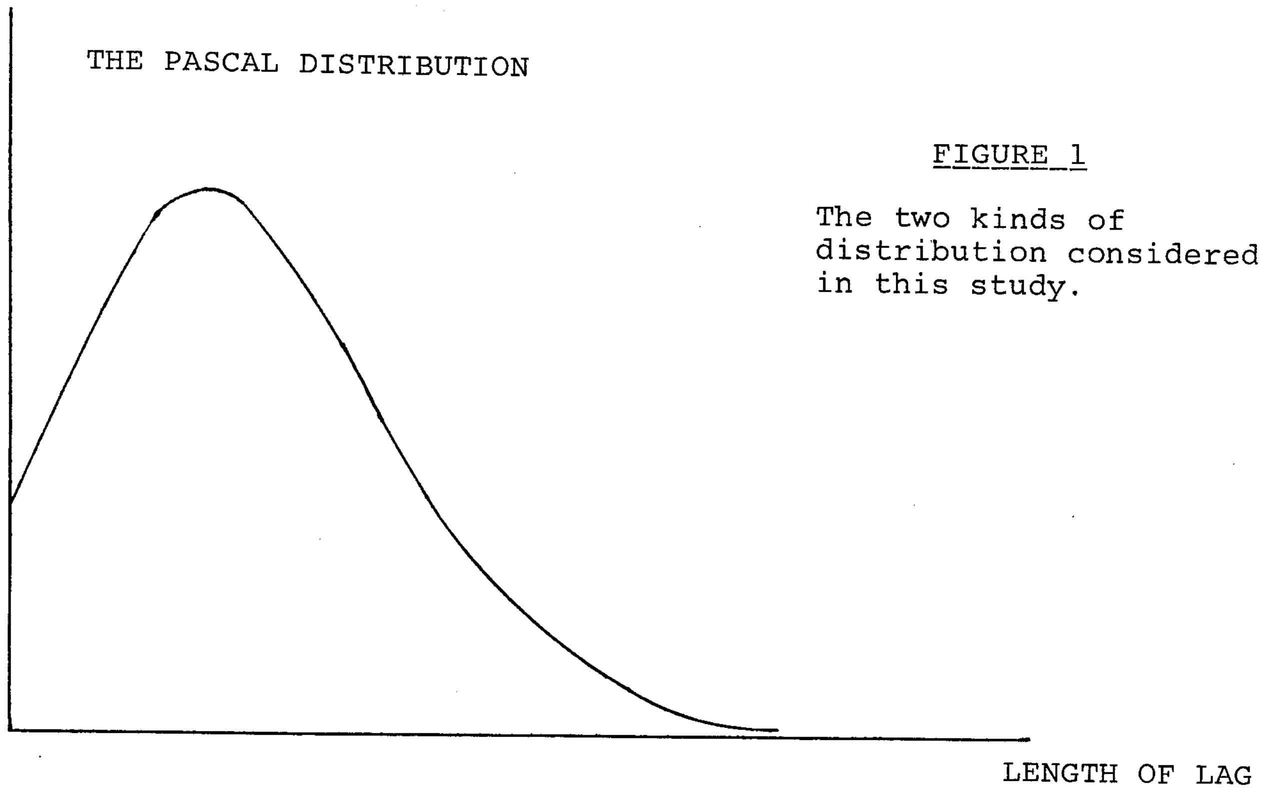
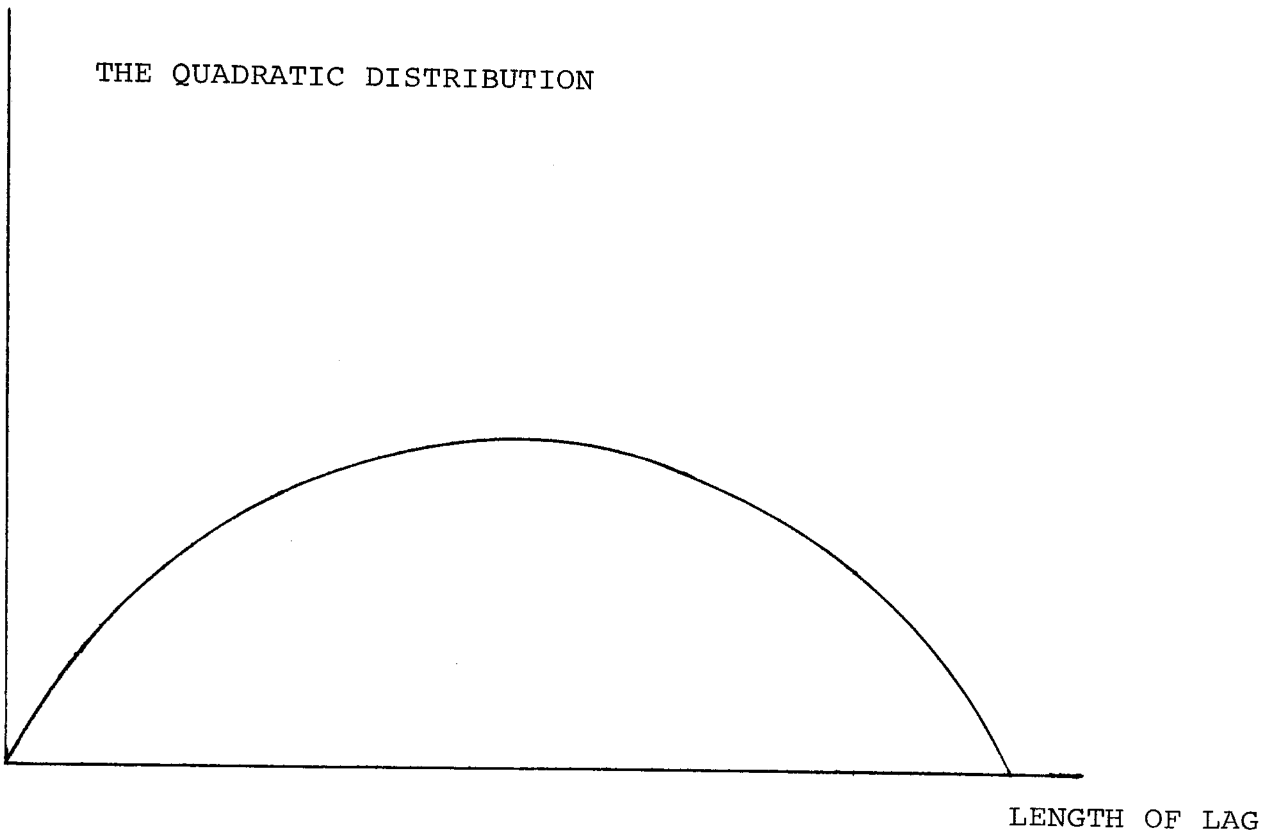


FIGURE 1

The two kinds of distribution considered in this study.



$$(1) \qquad \log \frac{LF_{it}}{POP_{it}} = \alpha_o + \alpha_1 t + \alpha_2 \log \frac{M_t}{POP_t} + \alpha_3 L(\log WR_{t-j}) + \mu_t \quad ,$$

where the t subscripts refer to period t and where $L(\log WR_{t-j})$ denotes the distributed lag of log WR. A time trend is added to the equation to pick up any trend effects not captured by the other explanatory variables. The reason the log form of the equation is used will be clear below. The error term in equation (1), μ_t, is assumed to be first order serially correlated, and all of the equations below were estimated to take this correlation into account.[2]

The Case of Money Illusion

In the short run it may be that labor force participants do not respond directly to changes in the real wage, but instead respond in a more complicated way to changes in the money wage and the price level. Depending on the speed with which information on wage and price changes becomes available, people may respond more quickly to one change than to another. Only in the long run may it be the case that the response is primarily to the real wage. If, for example, people respond more quickly to money wage changes than to price changes, they can be considered to be suffering from short-run money illusion. If, on the other hand, people respond more quickly to price changes, they can be considered to be suffering from "negative" short-run money illusion (to be referred to as short-run price illusion). Fortunately, the degree of short-run money or price illusion can be estimated.

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[2]The equations were estimated by the Cochrane-Orcutt iterative technique within the context of either the Almon method or the method described in the Appendix.

Let W denote the money wage rate and P the price level. Then the following equation can be estimated:

$$(2) \quad \log \frac{LF_i}{POP_i} = \alpha_o + \alpha_1 + \alpha_2 \log \frac{M_t}{POP_t} + \alpha_3 L_1(\log W_{t-j}) + \alpha_4 L_2(\log P_{t-j}) + \mu_t ,$$

where $L_1(\log W_{t-j})$ denotes the distributed lag of log W and $L_2(\log P_{t-j})$ denotes the distributed lag of log P. By definition WR equals W/P, or log WR = log W-log P, and if there is neither short-run nor long-run money and price illusion, then the distributed lag price term in equation (2) should be the exact negative of the distributed lag money wage term. If there is short-run but not long-run money (price) illusion, then the sum of the coefficients of the two distributions should be equal in absolute value, but the distributed lag money wage term should have larger (smaller) coefficients at the beginning of the distribution and smaller (larger) coefficients at the end in absolute value than the distributed lag price term does. If there is also long-run money (price) illusion, then the sum of the coefficients of the money wage distribution should be larger (smaller) than the sum of the coefficients of the price distribution. The degree of money or price illusion can thus be estimated by estimating the two separate lag distributions and observing their properties.

The money wage and the price level are fairly collinear, which can make it difficult to estimate separate lag distributions for these variables. Serious difficulties in this regard were encountered when attempts were made in this study to estimate freely more than one coefficient per distribution. As long as only one coefficient was freely estimated per distribution, however, multicollinearity problems appeared to be kept within bounds.

As will be seen below, a few problems were still encountered for some age-sex groups, but in general it appeared possible to get separate estimates for each distribution.

III. THE RESULTS

The Data and Period of Estimation

All of the equations were estimated for the 1956I - 1970II period, excluding observations for the third and fourth quarters of 1959 and the first quarter of 1960 because of the steel strike and for the fourth quarter of 1964 and the first two quarters of 1965 because of the automobile strike. The period of estimation thus consisted of 52 observations.

Sixteen age-sex groups were analyzed: males and females aged 16-17, 18-19, 20-24, 25-34, 35-44, 45-54, 55-64, and 65+.[3] The data on LF_i and POP_i are household survey data and were collected directly from the Bureau of Labor Statistics (BLS). Both LF_i and POP_i include people in the armed forces, and LF_i is seasonally adjusted. The data on M, POP, and W were also collected from the BLS. The data on M are primarily establishment based data and refer to the total level of employment in the private nonfarm sector; the data on POP refer to the total noninstitutional population 16 and over; and the data on W refer to the average level of hourly earnings in the private nonfarm sector. M and W are seasonally adjusted. The data on P refer to the quarterly average of the consumer price index. Establishment based data were used for the employment variable because of possible

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[3]Because of the cross section work of Mincer and Cain on married women, it would have been of interest to treat married and single women separately. Time series data are not available to do this, however, but since over 80 per cent of women between the ages of 25 and 54 are married (see, for example, U. N. Demographic Yearbook [8]), the results achieved in this study for women of these ages should be similar to the results that would have been achieved for married women of these ages had the data been available.

measurement errors in the household survey data. Household survey measurement errors are likely to show up in both the employment and labor force data, which will cause measurement error bias in equation (2) if household survey data are used for the employment variable. This bias can be corrected by using a two-stage least squares or instrumental variable technique, as was done for one of the labor force participation equations in Fair [3], but for present purposes it is somewhat easier to use the establishment based data for the employment variable.

With respect to the use of the aggregate wage rate variable, it is many times possible with cross section data to distinguish between the wage rate and potential income of the husband and the wage rate and potential income of the wife or other members of the family, but this is generally not possible with time series data. It is true, however, that average wage rates for different age-sex groups tend to move closely together over time, which means that the aggregate wage rate variable used in this study should be a reasonable proxy for the average wage rate of each group. Using the aggregate wage rate variable as a proxy for all wage rates means, of course, that it is not possible to separate income and substitution effects. Under the assumptions here, an increase in the aggregate wage rate increases the wage rate and potential income of both the husband and wife, as well as any other working members of the family, and it is thus not possible to isolate the pure substitution effect from the income and cross substitution effects. Only the <u>net</u> effect of the wage rate on the various participation rates can be estimated.

The Quadratic Distribution Results

When using the Almon technique, one must specify the length of each lag distribution. In this study five lengths were tried for each distribution: 4, 6, 8, 10, and 12 quarters. Since there are two distributions under consideration (one for log W and one for log P), this meant that $5^2 = 25$ regressions had to be run for each of the 16 age-sex groups. The summary results of these regressions are presented in Table 1. The first equation presented for each group is the equation that gave the best fit. For 6 of the 16 groups -- females 35-44, 55-64, males 16-17, 18-19, 20-24, 25-34 -- quite different results were obtained for similar fitting equations, and for these 6 groups a second equation is presented in Table 1. This second equation is the best fitting member of the set of equations that gave quite different results from the best overall fitting equation. The sum of the lag coefficients for each distribution is also presented in Table 1, as is the estimate of the first order serial correlation coefficient, ρ, for each equation.

The Pascal Distribution Results

Four Pascal distributions were considered in this study for the wage and price distributions. These four distributions are depicted in Figure 2 and are labeled A, B, C, and D. The first two, A and B, correspond to a peak response in the second quarter, and the second two, C and D, correspond to a peak response in the third quarter. A differs from B and C differs from D in that the initial responses are less strong and the overall response wears off more slowly. A length of 12 quarters was used for all of the Pascal regressions, which meant that $4^2 = 16$ regressions were run for each of the 16 age-sex groups. In addition, 16 other regressions were run for each group. These regressions were the same as the first 16 except that the first-quarter response was assumed to be zero and the Pascal distributions shifted to the right one quarter. The best fitting

TABLE 1: Estimates of Equation (2) Using (a) the Quadratic Distribution and (b) the Pascal Distribution

Group		Coefficient Estimates for								Length of Lag or Type of Distribution		Sum of Lag Coefficients	
		Const.	t	$\log(M_t/POP_t)$	$L_1(\log W_{t-j})$	$L_2(\log P_{t-j})$	ρ	R^2	SE	W	P	W	P
Females 16-17	(a)	-.20 (-0.04)	.013 (0.62)	2.69 (7.69)	-.38 (-0.96)	1.05 (1.50)	.22 (1.66)	.822	.0387	10	4	-2.80	3.34
	(b)	-2.37 (-0.65)	.006 (0.32)	2.97 (7.90)	-1.95 (-0.71)	2.95 (1.25)	.23 (1.71)	.820	.0389	C	A	-1.95	2.95
18-19	(a)	.35 (0.15)	.010 (0.92)	.64 (3.60)	-.29 (-1.08)	.56 (1.37)	.21 (1.57)	.527	.0217	8	4	-1.71	1.78
	(b)	-.35 (-0.18)	.007 (0.72)	.73 (3.62)	-1.35 (-0.91)	1.54 (1.21)	.20 (1.44)	.522	.0218	C	A	-1.35	1.54
20-24	(a)	-3.90 (-3.30)	-.012 (-2.47)	.27 (1.15)	.46 (2.83)	-.28 (-2.10)	.54 (4.59)	.967	.0145	6	8	2.11	-1.63
	(b)	-4.81 (-3.67)	-.014 (-2.44)	.13 (0.46)	2.38 (2.71)	-1.75 (-2.07)	.53 (4.53)	.967	.0145	A	D	2.38	-1.75
25-34	(a)	-3.54 (-3.71)	-.008 (-3.03)	.77 (5.55)	.23 (3.37)	-.10 (-1.64)	.39 (3.06)	.977	.0127	8	12	1.35	-.83
	(b)	-4.30 (-4.81)	-0.10 (-2.43)	.77 (5.23)	1.59 (2.52)	-.93 (-1.36)	.42 (3.30)	.977	.0128	D_{-1}	C_{-1}	1.59	-.93
35-44	(a)	.12 (0.10)	.011 (2.43)	.43 (4.57)	-.16 (-2.37)	.43 (3.38)	.29 (2.16)	.974	.0092	12	4	-1.40	1.38
	(a)	-2.80 (-3.94)	-.004 (-2.40)	.44 (3.96)	.15 (2.68)	-.03 (-0.74)	.38 (2.92)	.972	.0097	6	12	.67	-.25
	(b)	-3.14 (-4.76)	-.005 (-1.81)	.50 (4.59)	.86 (1.86)	-.38 (-0.75)	.39 (3.08)	.971	.0097	D_{-1}	C_{-1}	.86	-.38

TABLE 1 (cont)

Group			Const.	t	$\log(M_t/POP_t)$	$L_1(\log W_{t-j})$	$L_2(\log P_{t-j})$	ρ	R^2	SE	Length of Lag or Type of Distribution W	P	Sum of Lag Coefficients W	P
	45-54	(a)	-5.46 (-3.51)	-.012 (-2.01)	-.31 (-2.54)	.21 (2.37)	-.32 (-1.95)	.55 (4.79)	.971	.0087	12	4	1.82	-1.02
		(b)	-3.18 (-2.23)	-.004 (-0.61)	-.48 (-3.12)	.88 (0.90)	-.53 (-0.65)	.59 (5.26)	.969	.0091	C	A	.88	-.53
	55-64	(a)	.80 (1.21)	.013 (9.24)	.24 (2.09)	-.33 (-4.96)	.09 (2.56)	.27 (2.03)	.985	.0102	4	12	-1.05	.75
		(a)	-2.52 (-2.02)	-.007 (-1.52)	.11 (1.05)	.22 (2.93)	-.55 (-3.99)	.27 (2.01)	.984	.0103	12	4	1.88	-1.77
		(b)	2.00 (3.16)	.016 (5.63)	.24 (1.76)	-1.38 (-3.18)	.84 (1.87)	.30 (2.23)	.983	.0106	A	C	-1.38	.84
	65+	(a)	-17.88 (-3.00)	-.071 (-2.66)	.23 (0.61)	1.06 (2.53)	-1.42 (-2.37)	.37 (2.89)	.590	.0038	12	6	9.15	-6.50
		(b)	-10.53 (-2.27)	-.047 (-1.89)	-.44 (-0.88)	6.42 (1.77)	-5.25 (-1.64)	.52 (4.34)	.573	.0039	C_{-1}	A_{-1}	6.42	-5.25
Males	16-17	(a)	4.92 (1.83)	.019 (1.21)	1.85 (8.57)	-.36 (-2.30)	.78 (2.69)	.42 (3.38)	.912	.0180	12	4	-3.11	2.50
		(a)	-.31 (-0.20)	-.013 (-3.12)	1.92 (8.50)	.25 (2.24)	-.16 (-1.65)	.46 (3.78)	.907	.0185	8	12	1.47	-1.37
		(b)	-1.42 (-1.00)	-.014 (-2.24)	1.95 (8.23)	1.54 (1.54)	-1.19 (-1.11)	.47 (3.87)	.903	.0189	D_{-1}	C_{-1}	1.54	-1.19
	18-19	(a)	3.49 (1.09)	.019 (1.40)	.27 (1.34)	-.37 (1.71)	.60 (1.97)	.58 (5.15)	.892	.0145	12	6	-3.19	2.74
		(a)	-1.76 (-1.09)	-.009 (-2.46)	.04 (0.15)	.26 (1.51)	-.06 (-0.75)	.64 (6.01)	.889	.0146	4	12	.82	-.55
		(b)	-3.19 (-1.60)	-.013 (-1.45)	.02 (0.07)	1.28 (1.01)	-.73 (-0.66)	.65 (6.17)	.888	.0147	A	A	1.28	-.73
	20-24	(a)	-.20 (-0.52)	.001 (1.20)	.08 (1.35)	-.08 (-2.68)	.05 (2.46)	.12 (0.91)	.844	.0069	6	12	-.35	.43
		(a)	-1.26 (-1.73)	-.007 (-2.29)	.07 (1.24)	.09 (2.07)	-.18 (-2.20)	.12 (0.90)	.837	.0071	12	4	.78	-.58
		(b)	.48 (1.35)	.003 (1.88)	.14 (1.83)	-.58 (-2.40)	.55 (2.17)	.16 (1.18)	.841	.0070	A	C	-.58	.55

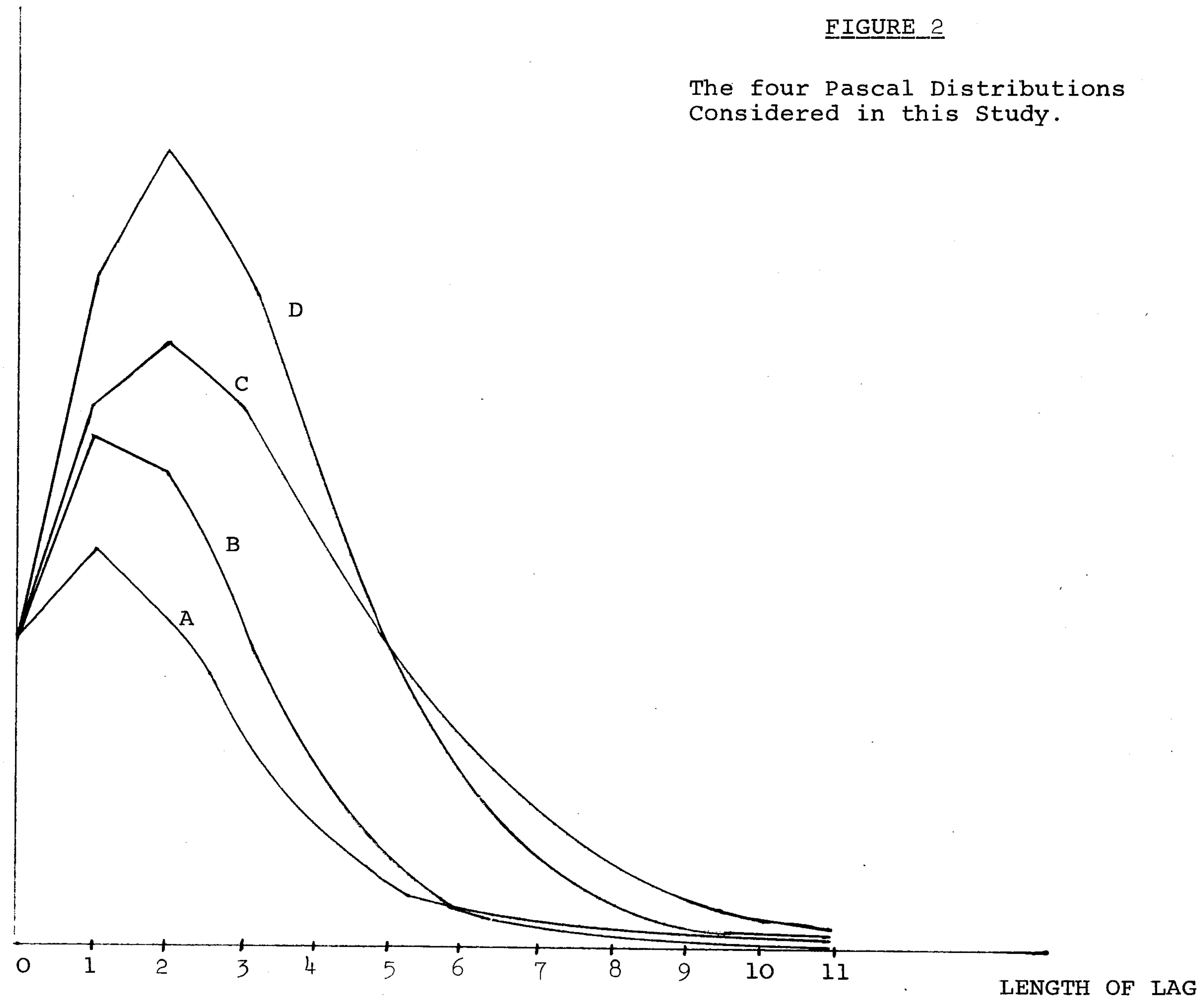
TABLE 1 (cont)

Group		Const.	t	$\log(M_t/POP_t)$	$L_1(\log W_{t-j})$	$L_2(\log P_{t-j})$	ρ	R^2	SE	Length of Lag or Type of Distribution W	P	Sum of Lag Coefficients W	P
25-34	(a)	-.09 (-0.30)	-.001 (-1.05)	-.01 (-0.24)	.02 (1.32)	-.07 (-1.98)	.29 (2.16)	.495	.0024	12	4	.20	-.21
	(a)	.33 (1.94)	.001 (2.74)	-.01 (-0.57)	-.03 (-2.10)	.01 (0.91)	.32 (2.45)	.486	.0025	8	12	-.15	.08
	(b)	.42 (2.78)	.001 (1.89)	.01 (0.19)	-.15 (-1.41)	.06 (0.58)	.32 (2.42)	.486	.0025	A	C	-.15	.06
35-44	(a)	.26 (1.12)	.002 (1.24)	-.01 (-0.43)	-.03 (-1.39)	.04 (1.40)	.15 (1.07)	.716	.0021	12	8	-.27	.23
	(b)	.16 (0.88)	.001 (1.02)	.01 (0.37)	-.16 (-1.24)	.14 (1.25)	.17 (1.25)	.714	.0021	C	B	-.16	.14
45-54	(a)	1.00 (4.18)	.004 (3.34)	-.02 (-1.25)	-.07 (-3.41)	.10 (2.86)	.17 (1.23)	.910	.0021	10	4	-.51	.32
	(b)	.53 (2.67)	.002 (1.53)	.01 (0.49)	-.26 (-1.57)	.16 (1.08)	.30 (2.28)	.898	.0022	C_{-1}	A_{-1}	-.26	.16
55-64	(a)	-.46 (-1.25)	.000 (0.01)	-.11 (-2.19)	-.03 (-0.75)	.04 (0.99)	.53 (4.45)	.964	.0038	12	12	-.22	.32
	(b)	-.36 (-1.11)	-.000 (-0.31)	-.10 (-1.85)	-.13 (-0.58)	.19 (0.80)	.54 (4.60)	.963	.0039	D_{-1}	B_{-1}	-.13	.19
65+	(a)	-6.98 (-4.59)	-.023 (-6.60)	1.15 (4.75)	.27 (2.20)	.03 (0.41)	.53 (4.56)	.986	.0165	6	12	1.22	.30
	(b)	-7.71 (-4.46)	-.031 (-3.47)	1.18 (4.99)	2.38 (1.82)	-.82 (-0.68)	.56 (4.85)	.986	.0164	D_{-1}	B_{-1}	2.38	-.82

t-statistics are in parentheses.

FIGURE 2

The four Pascal Distributions Considered in this Study.



equation of the 32 equations estimated is presented in Table 1 for each age-sex group. There were no problems with similar fitting equations giving quite different results for the Pascal distributions, and so only one equation is presented for each group using the Pascal distributions. The sum of the lag coefficients for each distribution is also presented in Table 1 for the Pascal results. In this case, the sum for each lag distribution is the same as the respective coefficient estimate, since the area under each Pascal distribution is one (ignoring the negligible area in the tail). Which Pascal distribution in Figure 2 was used for each equation is also listed in Table 1. The subscript -1 on A, B, C, or D in the table indicates that the best results were obtained from shifting the respective Pascal distribution one quarter to the right.

Tests for Short-Run and Long-Run Money or Price Illusion

It is quite easy to test for the existence of long-run money or price illusion. Given the estimate of the variance-covariance matrix of the coefficient estimates and given the particular lag distributions used, one can test in a fairly straightforward manner the hypothesis that the sum of the coefficients of the wage distribution is equal in absolute value to the sum of the coefficients of the price distribution. If the sums are significantly different from one another in absolute value, then this is evidence that there is long-run money or price illusion.

Testing for the existence of short-run money or price illusion is somewhat more complicated, but at least for the quadratic distribution results, the following test can be made. Compare the final equation chosen (i.e., the equation that gave the best fit) with equations estimated under the assumption that the length of the wage distribution is equal to the length of the price distribution -- in the present case either 4, 6, 8, 10, or 12 quarters. If an F test reveals that relaxing the restriction that the lengths of the wage and price distributions be equal does not significantly increase the fit of the equation, then accept the hypothesis that the lengths are equal; otherwise accept the hypothesis that the lengths are not equal. If the lengths are not equal, then this is evidence that people respond more quickly to one variable than to another and thus that there is short-run money or price illusion.

Evaluation of the Results

The easiest way to evaluate the results in Table 1 is to consider the unambiguous results first. The results for females 20-24 and 25-34 are clearly in this category. The money wage rate has a positive and the price level a negative effect on the participation rates for these two groups. For females 20-24 the estimated length of the quadratic lag distribution is 6 quarters for the wage rate and 8 quarters for the price level. For females 25-34 the lengths are 8 and 12 quarters respectively. The results for females 45-54 and 65+ also indicate that the money wage rate has a positive and the price level a negative effect on participation rates. In these two cases, the length of the quadratic lag distribution is longer for the wage rate than for the price level (12 quarters versus 4 and 6 quarters respectively). The size of the estimates for females 65+ is somewhat suspect. The estimate of the coefficient of the time trend is quite large in absolute value for both equations, and for all of the regressions run for this group there were indications of strong collinearity among the estimates of the time trend and of the coefficients of the price and wage distributions.

The results for females 16-17 and 18-19 indicate that the money wage rate has a negative and the price level a positive effect on participation rates. The results thus indicate that the real wage rate has a negative effect on the participation rates for these two groups, although none of the coefficient estimates of the wage and price terms are significant.

For females 35-44 and 55-64, the results are ambiguous. For females 35-44 the best fitting equation gives a negative effect for the money wage rate and a positive effect for the price level, with lags of length 12 and 4 quarters respectively, but a similar fitting equation gives the opposite effect, with lags of length 6 and 12 quarters. In the first equation the time trend has a significantly positive effect, and in the second equation it has a significantly negative effect. The best fitting Pascal equation gives a positive effect for the wage rate and a negative effect for the price level, although the estimates are not significant. There appears to be enough collinearity among the estimates of the time trend and of the coefficients of the wage and price distributions to prevent any definitive conclusions from being made as to whether the real wage rate has a positive or negative effect on the participation rate of this group. Likewise, for females 55-64 it is difficult to draw any conclusions. The time trend is positive and very significant in the two equations in which the money wage rate has a negative effect and is negative and insignificant in the equation in which the money wage rate has a positive effect.

The results are also ambiguous for males 16-17, 18-19, 20-24, and 25-34. For the first three groups the best fitting equation gives a negative effect for the money wage rate and a positive effect for the price level. The Pascal results are consistent with this for the third group, but run counter ot it for the first two groups. For the fourth group, the best fitting equation gives a positive effect for the money wage rate and a negative effect for the price level, but the Pascal results run counter to this.

For males 35-44, 45-54, and 55-64 the results indicate that the money wage rate has a small negative effect and the price level a small positive effect. The effects are small and generally not significant. For males 65+ the money wage rate has a positive effect and the price level either a small positive or small negative effect.

Despite the ambiguity of many of the results in Table 1, some general conclusions do emerge. There is, for example, little evidence of long-run money or price illusion. The sums are in general quite close in absolute value, and for none of the equations could the hypothesis that the sums are equal in absolute value be rejected at the 95 per cent confidence level. The sums for the money wage rate tends to be somewhat more dominant, but not enough to call into question the basic conclusion of no long-run money or price illusion.

For males between the ages of 20 and 64, wage rate effects are small and probably on the whole negative. While the results for males 20-24 and 25-34 are somewhat ambiguous, the overall results nevertheless indicate a small negative effect for males aged 20-64. The effects for the other males appear to be larger, with a definite positive wage rate effect for males 65+ and an uncertain effect for males 16-17 and 18-19.

The wage rate effects are in general larger for females than for males, and for females 20-24 and 25-34 there definitely appears to be a positive wage rate effect. This is consistent with the cross section results of Mincer and Cain. There is also evidence of a positive wage rate effect for females 45-54 and 65+, which together with the results for females 20-24 and 25-34 would argue on grounds of continuity that the ambiguous results for females 35-44 and 55-64 be interpreted as indicating a positive wage rate effect as well. For females 55-64, however, a negative wage effect cannot be ruled out. For females 16-17 and 18-19 the results indicate a negative wage rate effect.

With respect to the quadratic and Pascal distributions, the use of the quadratic distribution led to somewhat better results. Only for males 65+ was the fit better using the Pascal distribution. The quadratic distribution had the advantage of allowing the length of the lag distributions to vary more, however, and in general the results using the two types of distributions are close.

With respect to the tests for short-run money or price illusion (using the quadratic distribution results only), for ten of the sixteen groups -- females 16-17, 18-19, 20-24, 25-34, males 18-19, 20-24, 25-34, 35-44, 55-64, 65+ -- the fit of the best fitting equation was not significantly different at the 95 per cent confidence level from the fit of one or more of the equations estimated under the assumption of equal lag-distribution lengths. For the other six groups -- females 35-44, 45-54, 55-64, 65+, males 16-17, 45-54 -- the fit of the best fitting equation was significantly better than the fit of any of the equal length equations. For all but one of these six groups -- females 55-64 -- the length of the money wage distribution is longer than the length of the price distribution. The results for females 55-64 are again ambiguous, since the fit of both quadratic equations in Table 1 was better than the fit of any of the equal length equations and yet the first quadratic equation in Table 1 has lengths of 4 and 12 quarters respectively for the wage and price distributions while the second has lengths of 12 and 4 quarters respectively. In summary, therefore, for five of the groups there appears to be a significantly faster response to the price level than to the money wage rate and thus some element of short-run price illusion; for ten of the groups there is little evidence of either short-run price or money illusion; and for one of the groups the results are ambiguous. Overall, the results indicate that the existence of short-run money or price illusion is not very pronounced.

A number of other results are also of interest in Table 1. The coefficient estimate for the employment variable is positive and quite significant for females 16-17, 18-19, 25-34, 35-44, and males 16-17, 65+. For females 16-17 and males 16-17, 65+, the coefficient estimate is greater than one, which means that a given percentage change in the aggregate employment-population ratio results in a larger percentage change in the participation rates of these groups. The coefficient estimate is negative and significant for females 45-54. For the other groups the estimate is generally small and not significant, and for males between the ages of 18 and 54 there is no evidence that participation rates are affected by the employment-population ratio.

The time trend is generally either significantly negative or insignificant in Table 1. Only for males 45-54 does it appear to be significant and unambiguously positive (although even here the effect is small). For females 35-44, 55-64, and males 25-34 the time trend is significantly positive for one of the quadratic distribution equations, but not for the other. For these three groups, collinearity problems prevent any definitive conclusions from being drawn about the influence of the time trend. The overall results with respect to the time trend are thus somewhat striking and indicate that the unexplained trend in labor force participation rates is either zero or negative. In particular, it is interesting to note that the rapid increase in the labor force participation of groups like females 20-24 and 25-34 in the last half of the 1960's appears capable of being explained by rising real wage rates and the generally rising employment-population ratio.

Finally, it should be noted that the estimate of the serial correlation coefficient has ranged from near zero to .65 in Table 1. Overall, serial correlation problems appear to be fairly moderate.

APPENDIX: The Estimation of Pascal Distributions

The Pascal distribution is a function of two parameters, λ and r, and can be written:

$$\text{(A1)} \qquad P_i(\lambda,r) = \binom{r+i-1}{i}(1-\lambda)^r\lambda^i \qquad , i = 0,1,2,\ldots \quad .$$

In general, the parameter r in (A1) need not be an integer, but nonintegral values of r correspond to the negative binomial distribution and are not of interest here. In fact, only certain pairs of λ and r lead to distributions that are of interest for estimation purposes. The four distributions that were considered in this study are depicted in Figure 2 of the text and correspond to following pairs of λ and r: .33, 4; .45, 4; .17, 10; .22, 10. There are, of course, many other pairs of values of λ and r that lead to distributions similar to those depicted in Figure 2.

Solow [6] considered estimating the following distributed lag:

$$\text{(A2)} \qquad y_t = \sum_{i=0}^{\infty} \alpha_i x_{t-i} + u_t$$

by assuming that the α_i coefficients are distributed according to the Pascal distribution:

$$\text{(A3)} \qquad \alpha_i = \beta \binom{r+i-1}{i}(1-\lambda)^r\lambda^i \qquad , i = 0,1,2,\ldots \quad .$$

Solow proposed ways in which the parameters β, r, and λ of (A2) and (A3) might be estimated, but unfortunately the estimation procedures are complex and have not been widely used. A simpler approach is to assume that after a given number of periods (say, N) the α_i coefficients are zero, so that (A2) can be written:

$$(A4) \qquad y_t = \sum_{i=0}^{N-1} \alpha_i x_{t-i} + u_t \quad .$$

Combining (A3) and (A4) then yields:

$$(A5) \qquad y_t = \beta[(1-\lambda)^r \sum_{i=0}^{N-1} \binom{r+i-1}{i} \lambda^i x_{t-i}] + u_t = \beta Z(\lambda,r,N) + u_t \, ,$$

where $Z(\lambda,r,N)$ denotes the expression in brackets and is a function of λ, r, and N.

For given values of λ, r, and N, equation (A5) is a function of only one coefficient, β, and can be estimated by ordinary least squares. One can thus estimate equation (A5) by choosing various sets of values of λ, r, and N, estimating the equation by ordinary least squares for each set, and choosing that set that minimizes the sum of squared residuals. This scanning procedure is made easier by the fact that r must be an integer and that λ can be taken to lie between zero and one. In addition, for a given value of N, only certain pairs of λ and r will give reasonable looking distributions, and the possible values of λ and r can be further restricted in this way. Finally, one is likely to have a fairly good idea of the upper and lower bounds on N, which should also restrict the number of scans that have to be made. The values of $\binom{r+i-1}{i}$ can be readily looked up in tables, and with present day computers it is quite easy to print or plot out $P_i(\lambda,r)$ in (A1) for various values of λ and r (and for a large number of i's) to see which sets of values of λ and r correspond to reasonable looking distributions.

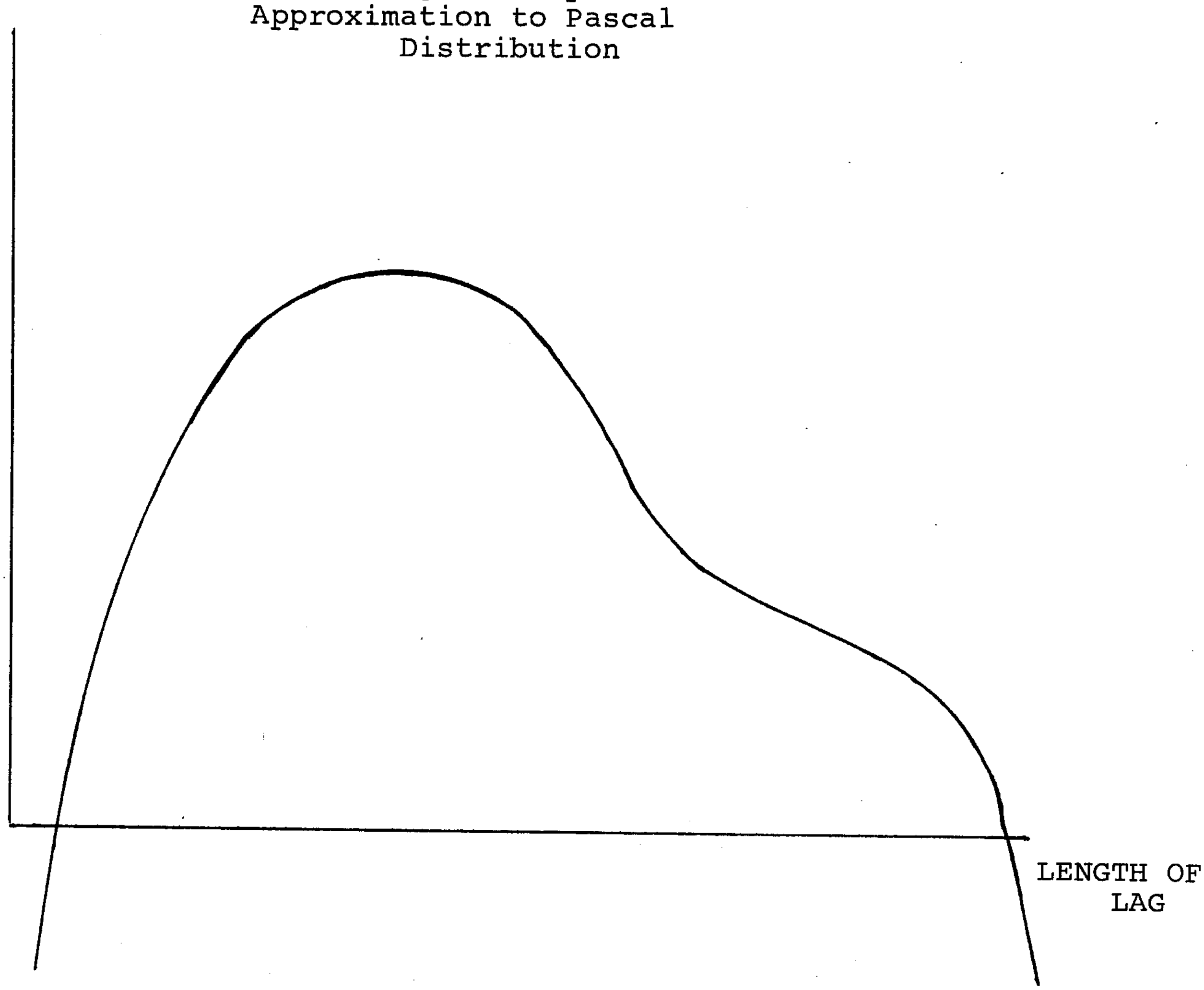
For practical purposes the assumption that the α_i coefficients are zero after a certain number of periods is not likely to be very restrictive, and by assuming this, the estimation problem is made more tractable. One is, of course, using a priori information to specify the shape of the lag distribution, but one is doing this whether an infinite tail is assumed for the distribution or not.

A Note on the Estimation of Polynomial (Almon) Distributions

Instead of using the Pascal distribution as an alternative to the (symmetrical) quadratic distribution, third or fourth degree polynomial distributions could perhaps have been tried in this study. The disadvantage with doing this -- a disadvantage that does not appear to be widely appreciated in the literature -- is that one generally does not believe that the lag distribution is shaped like a general third or fourth degree polynomial. Rather the lag distribution is usually believed to be more smoothly shaped -- generally something like the Pascal distribution. Now, a third degree polynomial does not provide a good approximation to a Pascal shaped distribution, and in order to get a reasonable approximation, one has to go to a fourth degree polynomial. Even here, however, it is a specific fourth degree polynomial, like the one depicted in Figure A-1, that provides a reasonable approximation, and not any general fourth degree polynomial. Information, in other words, is usually being lost when general third or fourth degree polynomial distributions are estimated. Chances of collinearity problems arising are also increased when general third or fourth degree polynomial distributions are estimated because of the fairly

FIGURE A-1

Fourth Degree Polynomial Approximation to Pascal Distribution



large number of coefficients involved. What one should do is restrict the polynomial to be of a specific type (such as the one in Figure A-1) and estimate restricted polynomial distributions. This will provide more efficient estimates (since less information is being thrown away) and will lessen the changes of collinearity problems arising because of the fewer number of coefficients being freely estimated. For purposes of this study further experimentation with different lag distributions did not appear to be necessary, especially considering the fact that only one coefficient could be freely estimated per distribution, but for other purposes estimating restricted polynomial distributions may prove to be useful.