# Inflation and Highway Economy Studies

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The nature of inflation and other price changes is investigated to determine procedures for treating them in highway economy studies. Long-and short-term trends of general inflation and highway costs are calculated to aid in future prediction. Current prices should be used for estimates of future costs and benefits because it is difficult to predict inflation or differential highway cost trends. In instances of great certainty of differential price trends, they should be used, but only in a sensitivity analysis.

•THE FACT that inflation has been a feature of the American economy for many years is a matter of record. For example, food purchased for $1.00 in 1940 cost about $2.60 in 1963. Clothing prices increased about 110 percent during the same period. In the highway field, construction costs had an average compounded annual increase of about 4 percent for the same period (Tables 1 and 2). Figure 1 shows the general rise in prices as measured by the Consumer Price Index, the Wholesale Price Index and Gross National Product Deflators.

TABLE 1

WHOLESALE PRICE, CONSUMER PRICE, AND GNP DEFLATOR INDEXES, 1913-1963

| Year | Wholesale[a] Price | Consumer[a] Price | GNP[b] Deflator | Year | Wholesale Price | Consumer Price | GNP Deflator |
|---|---|---|---|---|---|---|---|
| 1913 | 38.2 | 34.5 | - | 1938 | 43.0 | 49.1 | 48.7 |
| 1914 | 37.3 | 35.0 | - | 1939 | 42.2 | 48.4 | 48.1 |
| 1915 | 38.0 | 35.4 | - | 1940 | 43.0 | 48.8 | 48.9 |
| 1916 | 46.8 | 38.0 | - | 1941 | 47.8 | 51.3 | 52.9 |
| 1917 | 64.3 | 44.7 | - | 1942 | 54.0 | 56.8 | 59.6 |
| 1918 | 71.7 | 52.4 | - | 1943 | 56.5 | 60.3 | 64.9 |
| 1919 | 75.8 | 60.3 | - | 1944 | 56.9 | 61.3 | 66.5 |
| 1920 | 84.5 | 69.8 | - | 1945 | 57.9 | 62.7 | 68.0 |
| 1921 | 53.4 | 62.3 | - | 1946 | 66.1 | 68.0 | 74.6 |
| 1922 | 52.9 | 58.4 | - | 1947 | 81.2 | 77.8 | 83.0 |
| 1923 | 55.1 | 59.4 | - | 1948 | 87.9 | 83.8 | 88.5 |
| 1924 | 53.6 | 59.6 | - | 1949 | 83.5 | 83.0 | 88.2 |
| 1925 | 56.6 | 61.1 | - | 1950 | 86.8 | 83.8 | 89.5 |
| 1926 | 54.8 | 61.6 | - | 1951 | 96.7 | 90.5 | 96.2 |
| 1927 | 52.3 | 60.5 | - | 1952 | 94.0 | 92.5 | 98.1 |
| 1928 | 53.0 | 59.7 | - | 1953 | 92.7 | 93.2 | 99.0 |
| 1929 | 52.1 | 59.7 | 57.4 | 1954 | 92.9 | 93.6 | 100.0 |
| 1930 | 47.3 | 58.2 | 55.4 | 1955 | 93.2 | 93.3 | 101.2 |
| 1931 | 39.9 | 53.0 | 49.9 | 1956 | 96.2 | 94.7 | 104.6 |
| 1932 | 35.6 | 47.6 | 44.9 | 1957 | 99.0 | 98.0 | 108.4 |
| 1933 | 36.1 | 45.1 | 44.2 | 1958 | 100.4 | 100.7 | 110.8 |
| 1934 | 41.0 | 46.6 | 46.9 | 1959 | 100.6 | 101.5 | 112.6 |
| 1935 | 43.8 | 47.8 | 47.4 | 1960 | 100.7 | 103.1 | 114.2 |
| 1936 | 44.2 | 48.3 | 47.7 | 1961 | 100.3 | 104.2 | 115.7 |
| 1937 | 47.2 | 50.0 | 49.5 | 1962 | 100.6 | 105.4 | 116.9 |
| | | | | 1963 | 99.9 | 106.2 | 118.7 |

[a] Data derived from Ref. 8.
[b] Data derived from Ref. 6.

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TABLE 2

CALCULATION OF AVERAGE ANNUAL COMPOUND PRICE INCREASES[a]

| Year | Index No. | Period | n | Ratio | $(1+i)^n$ | i (%) |
|---|---|---|---|---|---|---|
| | | (a) Consumer Price Index | | | | |
| 1913 | 34.5 | 1913-1963 | 50 | 106.2/ 34.5 | 3.08 | 2.3 |
| 1929 | 59.7 | 1929-1963 | 34 | 106.2/ 59.7 | 1.73 | 1.6 |
| 1940 | 48.8 | 1940-1963 | 23 | 106.2/ 48.8 | 2.18 | 3.5 |
| 1957 | 94.7 | 1940-1957 | 17 | 94.7/ 48.8 | 1.94 | 4.0 |
| 1963 | 106.2 | 1957-1963 | 6 | 106.2/ 94.7 | 1.12 | 1.9 |
| | | (b) Wholesale Price Index | | | | |
| 1913 | 38.2 | 1913-1963 | 50 | 99.9/ 38.2 | 2.61 | 1.9 |
| 1929 | 52.1 | 1929-1963 | 34 | 99.9/ 52.1 | 1.92 | 1.9 |
| 1940 | 43.0 | 1940-1963 | 23 | 99.9/ 43.0 | 2.32 | 3.7 |
| 1957 | 99.0 | 1940-1957 | 17 | 99.0/ 43.0 | 2.3 | 5.0 |
| 1963 | 99.9 | 1957-1963 | 6 | 99.9/ 99.0 | 1.01 | 0.2 |
| | | (c) Engineering News-Record Construction Cost Index | | | | |
| 1913 | 100.0 | 1913-1963 | 50 | 900.7/100.0 | 9.01 | 4.5 |
| 1929 | 207.0 | 1929-1963 | 34 | 900.7/207.0 | 4.34 | 4.4 |
| 1940 | 242.0 | 1940-1963 | 23 | 900.7/242.0 | 3.72 | 5.9 |
| 1957 | 723.9 | 1940-1957 | 17 | 723.9/242.0 | 2.99 | 6.7 |
| 1963 | 900.7 | 1957-1963 | 6 | 900.7/723.9 | 1.25 | 3.8 |
| | | (d) U. S. Bureau of Public Roads Highway Cost Index | | | | |
| 1913 | - | - | - | - | - | - |
| 1929 | 55.0 | 1929-1963 | 34 | 101.7/ 55.0 | 1.85 | 1.8 |
| 1940 | 42.8 | 1940-1963 | 23 | 101.7/ 42.8 | 2.38 | 3.9 |
| 1957 | 103.1 | 1940-1957 | 17 | 103.1/ 42.8 | 2.41 | 5.3 |
| 1963 | 101.7 | 1957-1963 | 6 | (103.1/101.7) | (1.015) | -0.3 |
| | | (e) Gross National Product Deflators | | | | |
| 1913 | - | - | - | - | - | - |
| 1929 | 57.4[b] | 1929-1963 | 34 | 118.7/ 57.4 | 2.07 | 2.5 |
| 1940 | 48.9[b] | 1940-1963 | 23 | 118.7/ 48.9 | 2.42 | 3.9 |
| 1957 | 108.4[b] | 1940-1957 | 17 | 108.4/ 48.9 | 22.2 | 4.8 |
| 1963 | 118.7[b] | 1957-1963 | 6 | 118.7/108.4 | 1.095 | 1.5 |

[a]Values for indexes given in Tables 1, 3, and 4.
[b]Index = deflator.

The problem is how to consider inflation in highway economy studies. Should general trends in prices be included or only differential price changes, i.e., the difference between the price trend of the goods and services being analyzed and the general rate of inflation? Should all price trends, general and differential, be ignored? The answers to these questions are important because the procedure adopted for the treatment of inflation can have a decided effect on decisions between alternatives and on the justification of expenditures.

To answer these questions, we must have an understanding of inflation: its causes and cures, its future outlook, its measurement, and its effects on decisions.

This paper deals primarily with the treatment of inflation in economy studies, not in studies of financial feasibility. Economic analysis helps answer the questions "Why do it at all?" "Why do it this way?" "Why do it now?" Financial analysis helps answer the questions "Can it be financed?" "Who will bear the burden?" Both economic and financial studies are required before rational decisions can be reached; but the handling of inflation should be different for these

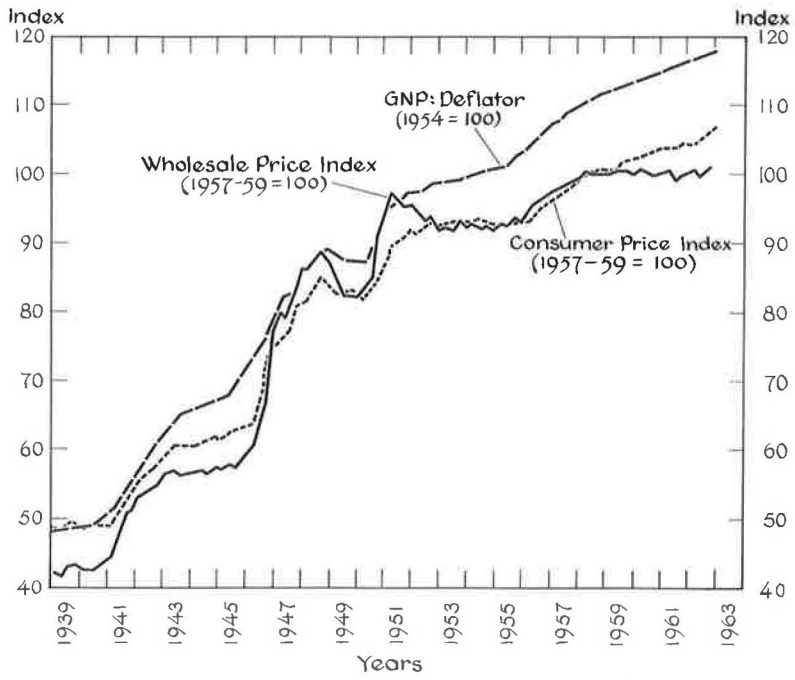


Figure 1. General price trends (24).

# TABLE 3

## PRICE TRENDS FOR FEDERAL-AID HIGHWAY CONSTRUCTION, 1957-1959 BASE[a]

| YEAR | COMMON EXCAVATION | | SURFACING | | | | | STRUCTURES | | | | | | | COMPOSITE INDEX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | PORTLAND CEMENT CONCRETE | | BITUMINOUS CONCRETE | | SURFACING INDEX | REINFORCING STEEL | | STRUCTURAL STEEL | | STRUCTURAL CONCRETE | | STRUCTURES INDEX | |
| | BID PRICE (CU. YD.) | INDEX | BID PRICE (SQ. YD.) | INDEX | BID PRICE (TON) | INDEX | | BID PRICE (LB.) | INDEX | BID PRICE (LB.) | INDEX | BID PRICE (CU. YD.) | INDEX | | |
| INDEXES CONVERTED MATHEMATICALLY FROM 1925–29 BASE TO 1957–59 BASE | | | | | | | | | | | | | | | |
| 1922 | $0.40 | 102.5 | $2.28 | 56.9 | " | " | 56.9 | $0.050 | 38.1 | $0.074 | 37.8 | $20.18 | 36.6 | 37.2 | 43.2 |
| 1923 | .47 | 119.3 | 2.43 | 60.6 | " | " | 60.6 | .057 | 43.4 | .078 | 39.4 | 23.37 | 42.4 | 40.5 | 50.4 |
| 1924 | .43 | 109.4 | 2.40 | 59.9 | " | " | 59.9 | .057 | 43.4 | .077 | 38.8 | 22.91 | 41.6 | 41.9 | 47.6 |
| 1925 | .39 | 98.3 | 2.36 | 58.9 | " | " | 58.9 | .056 | 42.6 | .067 | 33.8 | 22.53 | 40.9 | 40.6 | 44.2 |
| 1926 | .26 | 98.8 | 2.29 | 57.1 | " | " | 57.1 | .053 | 40.3 | .074 | 37.3 | 22.76 | 41.3 | 40.6 | 41.8 |
| 1927 | .35 | 89.8 | 2.29 | 57.1 | " | " | 57.1 | .051 | 38.8 | .071 | 35.8 | 22.65 | 41.1 | 39.7 | 60.9 |
| 1928 | .34 | 85.9 | 2.10 | 52.4 | " | " | 52.4 | .049 | 37.3 | .067 | 33.8 | 21.22 | 38.5 | 37.6 | 56.9 |
| 1929 | .32 | 80.6 | 2.05 | 51.1 | " | " | 51.1 | .048 | 36.5 | .059 | 29.8 | 21.58 | 39.2 | 37.2 | 55.0 |
| 1930 | .30 | 77.3 | 1.86 | 46.4 | " | " | 46.4 | .045 | 34.2 | .061 | 30.8 | 20.08 | 36.4 | 35.0 | 51.2 |
| 1931 | .27 | 69.5 | 1.68 | 41.9 | " | " | 41.9 | .040 | 30.4 | .054 | 27.2 | 18.02 | 32.7 | 31.3 | 45.9 |
| 1932 | .18 | 45.8 | 1.44 | 35.9 | " | " | 35.9 | .034 | 25.9 | .046 | 23.2 | 19.33 | 27.8 | 26.6 | 36.4 |
| 1933 | .26 | 66.2 | 1.67 | 41.6 | " | " | 41.6 | .038 | 28.9 | .046 | 23.2 | 16.15 | 29.3 | 28.2 | 45.8 |
| 1934 | .29 | 74.6 | 1.90 | 47.4 | " | " | 47.4 | .043 | 32.7 | .053 | 26.7 | 17.73 | 32.2 | 31.6 | 50.2 |
| 1935 | .26 | 65.6 | 1.90 | 47.4 | " | " | 47.4 | .044 | 33.5 | .052 | 26.2 | 17.78 | 32.3 | 31.9 | 48.1 |
| 1936 | .26 | 67.0 | 1.91 | 47.6 | " | " | 47.6 | .046 | 35.0 | .060 | 30.3 | 20.25 | 36.8 | 35.2 | 49.5 |
| 1937 | .24 | 61.8 | 1.89 | 47.1 | " | " | 47.1 | .048 | 36.5 | .066 | 33.3 | 19.76 | 35.9 | 35.8 | 47.4 |
| 1938 | .21 | 53.5 | 1.72 | 42.9 | " | " | 42.9 | .045 | 34.2 | .063 | 31.8 | 19.06 | 34.6 | 34.1 | 43.5 |
| 1939 | .21 | 53.5 | 1.73 | 43.1 | " | " | 43.1 | .044 | 33.5 | .059 | 29.8 | 19.13 | 34.7 | 33.6 | 43.4 |
| 1940 | .21 | 53.0 | 1.68 | 41.9 | " | " | 41.9 | .045 | 34.2 | .063 | 31.8 | 19.17 | 34.8 | 34.3 | 42.8 |
| 1941 | .24 | 62.0 | 1.87 | 46.6 | " | " | 46.6 | .054 | 41.1 | .076 | 38.3 | 21.44 | 38.9 | 39.4 | 48.6 |
| 1942 | .27 | 93.2 | 2.39 | 59.6 | " | " | 59.6 | .065 | 49.5 | .090 | 45.4 | 26.16 | 47.5 | 47.8 | 65.2 |
| 1943 | .44 | 111.0 | 2.71 | 67.6 | " | " | 67.6 | .067 | 51.0 | .095 | 47.9 | 30.19 | 54.8 | 52.6 | 74.6 |
| 1944 | .37 | 93.4 | 2.45 | 61.1 | " | " | 61.1 | .064 | 48.7 | .089 | 44.9 | 31.94 | 58.0 | 53.4 | 67.6 |
| 1945 | .36 | 92.0 | 2.38 | 59.4 | " | " | 59.4 | .062 | 47.2 | .077 | 38.8 | 31.62 | 57.4 | 51.8 | 65.1 |
| 1946 | .35 | 88.7 | 2.65 | 66.1 | " | " | 66.1 | .075 | 57.1 | .113 | 57.0 | 38.79 | 70.4 | 64.4 | 71.1 |
| 1947 | .38 | 97.0 | 3.01 | 75.1 | " | " | 75.1 | .093 | 70.8 | .132 | 66.6 | 45.84 | 83.2 | 77.0 | 80.6 |
| 1948 | .42 | 106.8 | 3.37 | 84.0 | " | " | 84.0 | .108 | 82.2 | .158 | 79.7 | 51.00 | 92.6 | 87.6 | 90.3 |
| 1949 | .38 | 96.2 | 3.40 | 84.8 | " | " | 84.8 | .104 | 79.1 | .146 | 73.7 | 47.36 | 86.0 | 82.3 | 87.1 |
| 1950 | .33 | 84.6 | 3.32 | 82.8 | " | " | 82.8 | .100 | 76.1 | .139 | 70.1 | 44.62 | 81.0 | 78.0 | 82.3 |
| INDEXES COMPUTED FROM 1957–59 BASE QUANTITIES AND PRICES | | | | | | | | | | | | | | | |
| 1950 | .32 | 75.7 | 3.62 | 82.7 | 5.89 | 88.5 | 85.7 | .099 | 76.2 | .129 | 66.1 | 42.62 | 78.7 | 74.2 | 78.3 |
| 1951 | .40 | 96.2 | 3.92 | 89.6 | 7.33 | 110.1 | 100.3 | .119 | 92.0 | .176 | 90.4 | 50.72 | 93.6 | 92.3 | 96.2 |
| 1952 | .43 | 102.4 | 4.19 | 95.7 | 6.98 | 104.8 | 100.5 | .119 | 92.4 | .178 | 91.3 | 52.24 | 96.4 | 94.1 | 98.9 |
| 1953 | .40 | 96.2 | 4.07 | 93.0 | 6.53 | 98.1 | 95.6 | .121 | 93.8 | .172 | 88.6 | 52.82 | 97.5 | 94.0 | 93.3 |
| 1954 | .38 | 91.4 | 3.98 | 90.9 | 5.97 | 89.7 | 90.3 | .112 | 86.7 | .159 | 82.5 | 50.15 | 92.6 | 88.0 | 89.9 |
| 1955 | .35 | 84.0 | 3.96 | 90.5 | 6.07 | 91.2 | 90.8 | .110 | 85.2 | .157 | 80.9 | 50.01 | 92.3 | 87.4 | 87.3 |
| 1956 | .40 | 96.0 | 4.26 | 97.3 | 6.58 | 98.8 | 98.1 | .127 | 97.9 | .212 | 108.9 | 53.74 | 99.2 | 102.0 | 98.8 |
| 1957 | .42 | 100.7 | 4.34 | 99.2 | 6.75 | 101.4 | 100.3 | .134 | 104.0 | .228 | 117.0 | 55.98 | 103.3 | 107.8 | 101.4 |
| 1958 | .43 | 103.9 | 4.41 | 100.8 | 6.67 | 100.2 | 100.5 | .129 | 99.9 | .186 | 95.7 | 54.10 | 99.9 | 98.5 | 100.6 |
| 1959 | .40 | 95.7 | 4.40 | 100.5 | 6.58 | 98.8 | 99.6 | .126 | 97.2 | .169 | 86.8 | 53.00 | 97.8 | 94.2 | 96.4 |
| 1960 | .39 | 93.6 | 4.33 | 98.9 | 6.37 | 95.7 | 97.2 | .119 | 92.1 | .187 | 89.6 | 51.72 | 95.5 | 91.7 | 94.1 |
| 1961 | | | | | | | | | | | | | | | |
| 1st Qtr. | .41 | 98.3 | 4.18 | 95.5 | 6.19 | 93.0 | 94.2 | .115 | 89.0 | .162 | 83.4 | 52.14 | 96.2 | 90.8 | 94.4 |
| 2nd " | .39 | 93.6 | 4.23 | 96.6 | 6.38 | 95.8 | 95.1 | .116 | 89.6 | .163 | 83.9 | 53.05 | 98.3 | 90.2 | 93.2 |
| 3rd " | .41 | 98.1 | 4.26 | 97.0 | 6.47 | 97.2 | 96.2 | .113 | 87.4 | .161 | 83.8 | 52.96 | 97.8 | 91.1 | 97.1 |
| 4th " | .41 | 98.6 | 4.38 | 100.1 | 6.34 | 95.2 | 97.5 | .116 | 89.5 | .172 | 88.5 | 55.40 | 102.3 | 95.6 | 97.2 |
| Average | .41 | 96.7 | 4.20 | 96.0 | 6.35 | 95.4 | 95.7 | .115 | 88.9 | .165 | 84.8 | 53.38 | 98.5 | 92.4 | 94.9 |
| 1962 | | | | | | | | | | | | | | | |
| 1st Qtr. | .45 | 106.2 | 4.28 | 97.8 | 6.20 | 93.1 | 95.3 | .111 | 86.2 | .161 | 82.7 | 52.66 | 97.2 | 90.6 | 97.4 |
| 2nd " | .43 | 101.0 | 4.23 | 96.6 | 6.42 | 96.4 | 96.5 | .114 | 88.2 | .168 | 86.2 | 54.28 | 100.2 | 93.6 | 97.0 |
| 3rd " | .45 | 106.2 | 4.26 | 97.0 | 6.37 | 95.7 | 95.4 | .113 | 87.6 | .165 | 84.6 | 54.79 | 101.1 | 93.4 | 98.4 |
| 4th " | .47 | 110.7 | 4.42 | 101.0 | 6.16 | 92.5 | 96.6 | .112 | 86.9 | .172 | 88.3 | 56.65 | 104.6 | 96.1 | 101.2 |
| Average | .45 | 106.2 | 4.28 | 97.8 | 6.28 | 94.3 | 96.0 | .113 | 87.1 | .166 | 85.5 | 54.62 | 100.8 | 93.5 | 98.6 |
| 1963 | | | | | | | | | | | | | | | |
| 1st Qtr. | .45 | 106.7 | 4.29 | 98.0 | 6.47 | 97.2 | 97.6 | .112 | 86.8 | .171 | 87.9 | 55.08 | 101.7 | 94.6 | 99.6 |
| 2nd " | .43 | 102.6 | 4.22 | 96.3 | 6.37 | 98.6 | 97.6 | .113 | 87.6 | .181 | 93.1 | 57.47 | 106.1 | 98.6 | 99.6 |
| 3rd " | .44 | 105.0 | 4.39 | 100.3 | 6.37 | 95.6 | 97.9 | .116 | 89.6 | .196 | 100.7 | 58.24 | 107.5 | 102.1 | 101.7 |
| 1957-59 Base | 0.42 | 100.0 | 4.38 | 100.0 | 5.66 | 100.0 | 100.0 | 0.129 | 100.0 | 0.195 | 100.0 | 54.18 | 100.0 | 100.0 | 100.0 |

[a]Data derived from Ref. 10.

two types of analysis. The treatment of inflation in financial studies is briefly discussed later in the paper.

## PRICE CHANGES DEFINED

Two types of price changes may be distinguished: inflation and differential price changes.

Although more elaborate definitions are sometimes use (1), (pp. 510-511), it is sufficient for our purposes to define inflation as an increase in the general level of prices and income throughout the economy, i. e., general price trends. No single index has been devised which can accurately measure inflation. The usual approach is to consider together the Consumer Price Index, the Wholesale Price Index and the Gross National Product Deflators.

By differential price changes we mean the difference between the price trends of the good or service being analyzed and the general price trend. During inflation some prices decrease, whereas others remain fairly constant, keep pace with, or exceed the general trend in prices. Some authorities recommend that differential price changes should be projected and included in the economic analysis; hence their relevance to this discussion.

Aside from inflation, prices may appreciate either because of an increased demand for a particular good or service or because of a diminished supply. This increased demand is often caused by changing consumer tastes. The diminished supply may occur because resources are being depleted in a particular area. An important factor in maintaining stable prices for certain goods and services is the improvement of technology which prevents unit costs from increasing in spite of inflation. This has been the case in the highway field, where average excavation costs were about $0.40/cu yd in 1922 compared with about $0.44/cu yd in 1963 (Table 3). These stable prices can be attributed to the advances in earthmoving equipment and techniques. Therefore, there has been a differential decrease in the cost of highway excavation when compared to the rate of inflation over the same period.

## CAUSES OF INFLATION

Two primary causes of inflation have been identified (1, pp. 511-516, and 2). One is the demand for goods and services increasing much more than the available supplies. The price rise thus stimulated is sometimes called demand-pull inflation. This often occurs when governments undertake large expenditures to finance war or national defense, or to encourage a rapid rate of economic growth. However, individuals and business also contribute to inflation by demanding more than can be produced at a given time. The inflation immediately following World War II is thought to have been caused mainly by pent-up consumer demands for goods and services. Competition for available supplies caused general price level increases.

The other cause of inflation has been attributed to wage increases exceeding increases in labor productivity. The inflation which occurs has been termed cost-push inflation (3). The relative effect of cost-push vs demand-pull factors in causing inflation is a matter of controversy, but it seems evident that inflation would have been less severe during the past decade if wages had not increased more rapidly than the productivity of labor.

## ECONOMIC EFFECTS OF INFLATION

Unexpected inflation favors debtors at the expense of creditors. Suppose someone had borrowed $1,000 a year ago to be repaid now. If prices have doubled in that period, he will be repaying only 50 percent of the real purchasing power received. He is benefiting at the expense of his creditor. Those receiving fixed incomes (from fixed pensions, life insurance annuities and interest) are injured by inflation and those receiving profits (from real estate, common stocks or commodities) are benefited. Similarly, a government agency which borrowed funds for public works projects during a period when inflation was not anticipated finds that its debt is more easily repaid with inflated dollars.

From the national viewpoint, the transfers that take place between debtors and creditors during periods of inflation tend to cancel one another. Therefore, unless

such transfers influence the production of goods and services (as they do during rapid inflation), they have no effect on the national income. In a period of creeping inflation, such as we have experienced in the United States, transfers of this type need not be considered in an economy study. It follows that there is no economic gain to the nation in accelerating the building of public works because inflation is anticipated. Nor is there any ground for public officials to congratulate themselves on having built projects when money costs were lower. If the purchasers of the bonds fail to anticipate inflation, they lose and the debtors gain. If inflation is anticipated correctly by the bond holders, they will probably demand a higher interest yield to compensate for inflation. There is still no net change from the national viewpoint (4).

On the other hand, from a local viewpoint, an area can benefit from having built public works during periods of low prices, provided that an inflation increment was not included in the interest rate on the bonds. In this case, the repayment of the debt can be made with inflated dollars which means that the real cost to the area is less than it would have been had inflation not occurred. A loss occurs to the creditors who failed to anticipate inflation, but this is generally of little concern to the local area.

## CURES FOR INFLATION

The techniques to be used by government to cope with demand-pull inflation are well known (5, pp. 22-24). To diminish demand to bring it into equilibrium with supply, the Federal Government can use both fiscal and monetary policy. Fiscal policy is concerned with taxation and expenditure measures, whereas monetary policy concerns actions affecting credit and the money supply. When serious inflation appears imminent, the government can increase taxes and reduce its expenditures or it can impose credit restrictions through the Federal Reserve Board. One problem in using these measures is that they may be politically unpopular since many groups gain during inflation. Another is that it is difficult to know to what extent and in what combination these measures can be applied to have stable prices and not deflation. There is the very real possibility that an overzealous dedication to the elimination of inflation will lead to depression and unemployment.

There are no similar stabilization tools available to the government to minimize the threat of cost-push inflation. Restraint on the part of business and labor is called for so that their actions will not contribute to inflation. When this restraint is not evident, the government may feel it necessary to intervene, as witnessed by President Kennedy's dramatic encounter with United States Steel in the spring of 1962. President Johnson has given clear warning that he is watching closely the actions of business and labor with regard to wage demands and price increases:

> In the face of a 44 percent increase in corporate profits in less than three years and the prospect of further increases to come with the tax cut, I see no warrant for inflationary price rises.
>
> On the heels of solid increases in real wages, plus the rise in take-home pay under the tax cut, I see no warrant for inflationary price rises. Accordingly:
>
> I shall keep a close watch on price and wage developments, with the aid of an early warning system which is being set up in the appropriate agencies.
>
> I shall not hesitate to draw public attention to major actions by either business or labor that flout the public interest in non-inflationary price and wage standards. (6, p. 1)

## FUTURE OUTLOOK FOR INFLATION

Notwithstanding increased knowledge of the causes and cures of inflation, few economists would be willing to predict that the problem has been eliminated. According to Musgrave:

> No one can predict whether the bias in years ahead will be toward inflation or deflation. Much depends on the outlook for peace and war and the resulting level of military expenditures in the budget. In any case, there is little reason to expect that stabilizing policy will become unnecessary. While much has been said in recent years about built-in stabilizers, these remain to be tested; and contrary to current belief, the inherent tendency toward instability may increase rather than decline as the economy develops and gains in complexity. (5, pp. 22-23)

Another economist, John Kenneth Galbraith, is of the opinion that inflation, not depression, is the greatest threat to the American free-enterprise system, since most of the forces in the economy are of an inflationary nature (7).

## MEASUREMENT OF PRICE CHANGES

Numerous indexes have been devised to measure past price trends for different goods and services. We are concerned with those used to (a) indicate general price trends and (b) gage price changes in the highway field. These may help in predicting future price trends.

### Measuring General Price Trends

Unfortunately, there is no single index completely satisfactory for measuring the general trend in prices, i.e., inflation or deflation. The three indexes commonly used are the Consumer Price Index, the Wholesale Price Index and the Gross National Product (GNP) Deflator. Each has certain shortcomings and cannot be relied on exclusively for measuring changes in price levels (3, pp. 9-14). Therefore, it is customary to look at all three when estimating what past inflation has been and what the future might hold.

The U. S. Department of Labor, Bureau of Labor Statistics, publishes regularly the Consumer Price Index and the Wholesale Price Index (8, pp. 348-358). The Department of Commerce publishes implicit GNP deflators which are included annually in the Economic Report of the President (6, pp. 214-215).

The Consumer Price Index measures:

> the average change in prices of goods and services purchased by city wage-earner and clerical-worker families. The weights used in calculating the index are based on studies of actual expenditures by families of wage earners and clerical workers. The quantities and qualities of the items in the "market basket" remain the same between consecutive pricing periods, so that the index measures the effect of price change only on the cost of living of these families. The index does not measure changes in the total amount families spend for living; city indexes do not measure relative differences in prices or living costs between cities....
>
> The list of items currently priced for the index includes approximately 300 goods and services. For some items, several different qualities are priced. The items priced are described by detailed specifications to insure that, as far as possible, the same quality is priced each time, and that differences in reported prices are measures of price change only. (8, pp. 348-350)

The Wholesale Price Index has been described by the Bureau of Labor Statistics as follows:

> This index, dating from 1890, is the oldest continuous statistical series published by the Bureau of Labor Statistics.

> It is designed to measure average changes in prices of commodities sold in primary markets in the United States.
>
> The index has undergone 4 major revisions....It is now based on nearly 2,200 commodity price series instead of the nearly 1,900 included in the 1947-60 period and the 900 included for the period prior to 1947. Prices used in constructing the index are collected directly from sellers, if possible, and apply as nearly as practicable to the first large volume commercial transaction for each commodity. (8, p. 350)

Gross National Product (GNP) is the total of all final goods and services produced by the economy in any period of time, usually quoted in yearly figures. GNP figures reflect inflation; therefore, the U. S. Department of Commerce has combined a number of price indexes to be used to remove general price level changes so that a true picture of economic growth can be given. This combined index has been described in this manner:

> By combining a number of appropriate price indexes, the U. S. Department of Commerce calculates price series which are comparable in coverage with the GNP. These measure the price changes in GNP from year to year and are known as "implicit price deflators." They can be used to remove the price element from the current dollar GNP series, resulting in GNP totals in constant dollars, often known as real income. (In economics, "real" means that changes in value have been eliminated.) In these terms, inflation would be the condition in which the deflator was rising, i.e., where national money income is rising faster than national real income. (3, p. 12)

## Measuring Price Trends in the Highway Field

Price indexes commonly used in the highway field are the Engineering News-Record Construction Cost (ENR) Index, the U. S. Bureau of Public Roads Highway Cost Index and individual state highway cost indexes. From these indexes we hope to gain some idea of the price trends in the highway field for comparison with the general price trend to calculate a differential price change, if any.

The ENR Index (Table 4) was created in 1921 to "diagnose the wild gyrations of prices during and immediately following World War I and to appraise their effect on construction costs." The components and weighting of the index are "25 cwt structural steel shapes, base mill price; 6 bbl portland cement, 20-cities average, bulk; 1.088 Mfbm 2 × 4, S4S lumber, 20-cities average; 200 hr common labor, 20-cities average" (9, p. 79).

The ENR Construction Index does not adjust for "productivity, black or grey markets, competitive conditions, mechanization, design changes or other 'intangibles' that affect the final cost to the owner, or the contractor's 'selling price'" (9, p. 80). Although this index may be satisfactory for some purposes, it should not be used uncritically. For example, it should not be used in the highway field because it neglects so many matters that influence highway costs. Better indexes are available to measure highway construction cost trends, e.g., the U. S. Bureau of Public Roads Highway Construction Cost Index. For the 1957-1959 base period, the index includes 3,641,885,000 cu yd of roadway excavation, 154,953,000 sq yd of portland cement surfacing with average thickness of 9.1 in., 111,516,000 tons of bituminous concrete surfacing, 2,206,879,000 lb of reinforcing steel for structures, 2,581,462,000 lb of structural steel, and 14,583,000 cu yd of structural concrete (10, p. 174). This is a nationwide index and should only be used when state highway cost indexes are not available. A sample of state highway price indexes can be found in Engineering News-Record (9, p. 98).

Figure 2 shows that the overall trend of highway prices appears to be fairly stable since 1957, as indicated by both the U. S. Bureau of Public Roads Index and the

TABLE 4

ENGINEERING NEWS-RECORD CONSTRUCTION COST INDEX,[a] 1903-1963

| Year | Annual Indexes | Year | Annual Indexes |
|---|---|---|---|
| 1903 | 93.90 | 1933 | 170.18 |
| 1904 | 87.40 | 1934 | 198.10 |
| 1905 | 90.55 | 1935 | 196.44 |
| 1906 | 95.10 | 1936 | 206.42 |
| 1907 | 100.55 | 1937 | 234.71 |
| 1908 | 97.20 | 1938 | 235.83 |
| 1909 | 90.92 | 1939 | 235.51 |
| 1910 | 96.33 | 1940 | 241.96 |
| 1911 | 93.43 | 1941 | 257.84 |
| 1912 | 90.70 | 1942 | 276.30 |
| 1913 | 100.00 | 1943 | 289.95 |
| 1914 | 88.56 | 1944 | 298.72 |
| 1915 | 92.58 | 1945 | 307.75 |
| 1916 | 129.58 | 1946 | 346.04 |
| 1917 | 181.24 | 1947 | 413.16 |
| 1918 | 189.20 | 1948 | 460.72 |
| 1919 | 198.42 | 1949 | 477.02 |
| 1920 | 251.28 | 1950 | 509.62 |
| 1921 | 201.82 | 1951 | 542.62 |
| 1922 | 174.45 | 1952 | 569.40 |
| 1923 | 214.12 | 1953 | 599.99 |
| 1924 | 215.36 | 1954 | 627.96 |
| 1925 | 206.68 | 1955 | 659.72 |
| 1926 | 208.03 | 1956 | 692.37 |
| 1927 | 206.24 | 1957 | 723.85 |
| 1928 | 206.78 | 1958 | 759.16 |
| 1929 | 207.02 | 1959 | 796.91 |
| 1930 | 202.85 | 1960 | 823.55 |
| 1931 | 181.35 | 1961 | 847.05 |
| 1932 | 156.97 | 1962 | 871.84 |
| | | 1963 | 900.73 |

[a]Data derived from Ref. 9.

California Highway Cost Index. It also shows how the ENR Index, which fails to reflect technological change, is without value in any study of trends in highway costs.

## Techniques for Calculating Price Changes

Two techniques used for measuring price changes are the arithmetic rate method and the compound rate method. The latter is employed here. However, both techniques will be briefly explained.

In the arithmetic rate method, the increase in price is divided by the number of years covered and the initial price to arrive at an annual arithmetic rate of increase. For example, if an item cost $100,000 in 1940 and $200,000 in 1960, the average arithmetic change in price per year is

$$i = (200,000-100,000)/20(100,000) = 0.05 = 5 \text{ percent}$$

The compound rate method is somewhat more complicated because it assumes that price changes proceed at an exponential rate. For the same data, the compound rate of price change would be

$$(1+i)^{20} = 200,000/100,000 = 2.0$$

$$(1+i) = (2.0)^{1/20}$$

$$i = (2.0)^{1/20} - 1.0$$

$$i = 1.035 - 1.0 = 0.035 = 3.5 \text{ percent}$$

The calculation of compound rates of price changes can be facilitated by referring to compound interest tables which have values of $(1+i)^n$ for various values of i and n (11).

## Summary of Past Price Changes

Table 5 gives an indication of the average annual compound rates of price changes for the indexes just reviewed. Rates are also calculated for short periods to show the variation with long-term trends.

Several conclusions can be reached by analyzing Table 5. The long-term general trend of prices as measured by the Consumer Price Index, the Wholesale Price Index and GNP Deflators has varied from 1.6 to 2.5 percent per year. Since 1957, these indexes have indicated rates of price increase from 0.2 to 1.9 percent per year. From 1940 to 1957, prices increased at rates from 4.0 to 5.0 percent per year. What rates may be expected in the future? As indicated earlier, projections of the trend of inflation are beset by great uncertainty. Long-term trends contain figures from periods when price stabilization tools were little understood. On the other hand, the growth of the threat of cost-push inflation and the increasing complexity of the economy prevent the optimistic view that inflation is under control. Since many observers feel that an annual rate of inflation of no more than 2 percent can be tolerated, this may give an upper limit. Since the long-term rates and the recent short-term rates approach

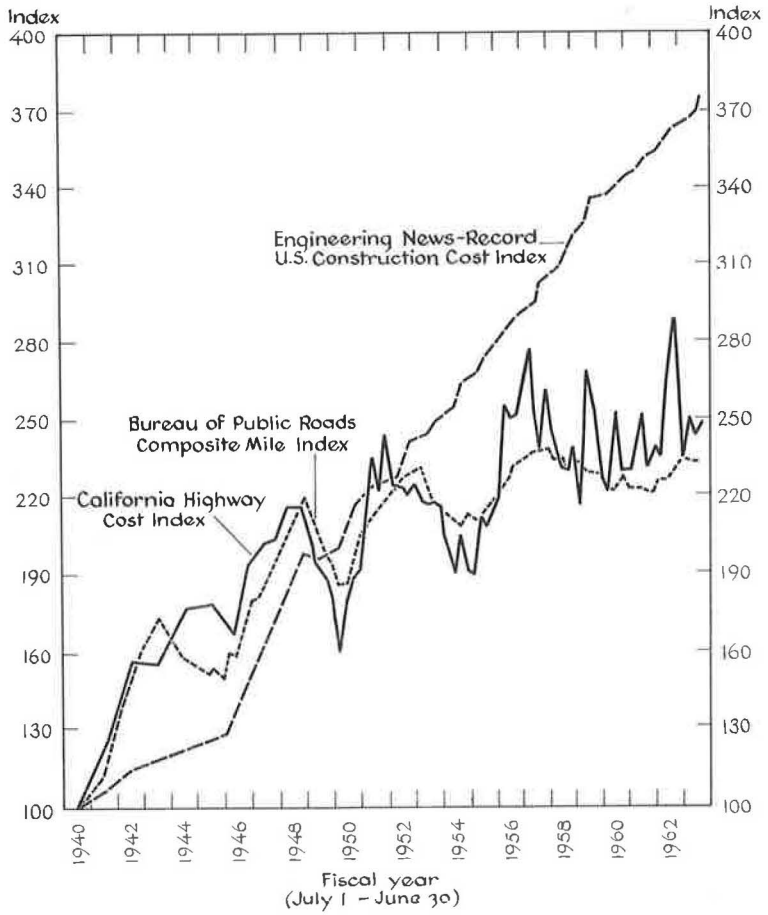


Figure 2. Price index-construction costs (12).

TABLE 5

AVERAGE ANNUAL PRICE CHANGES[a]

| Year | Compound Rates (%) | | | | |
|---|---|---|---|---|---|
| | Consumer Price | Wholesale Price | GNP Deflators | ENR Cost | BPR Highway Costs |
| 1913-1963 | 2.3 | 1.9 | — | 4.5 | — |
| 1929-1963 | 1.6 | 1.9 | 2.5 | 4.4 | 1.8 |
| 1940-1963 | 3.5 | 3.7 | 3.9 | 5.9 | 3.9 |
| 1940-1957 | 4.0 | 5.0 | 4.8 | 6.7 | 5.3 |
| 1957-1963 | 1.9 | 0.2 | 1.5 | 3.8 | -0.3 |

[a]Supporting data and calculations derived from Tables 1 through 4; calculations by slide rule rather than compound interest tables to get more accurate indications of price changes.

2 percent, perhaps this is as good an assumption as any, if a projection is to be made. Whether or not any projection should be made is discussed more fully later.

To find past differential price changes for highway costs, past highway cost trends must be determined for comparison with the general price trend. Table 6 indicates a great variation between price trend rates as computed from the Engineering News-Record Construction Cost Index and the U. S. Bureau of Public Roads Highway Cost Index. Although the ENR Index may be appropriate for some short-term purposes, it is inappropriate for measuring long-term price changes and obviously does not agree with the facts in the highway field. The Bureau of Public Roads Index reveals a long-term rate of about 1.8 percent with practically stable costs since 1957. However, from 1940 to 1957 costs increased by about 5.3 percent per year. Again, it is difficult to predict what future highway cost trends will be over any extended period of time. If we assume highway costs will

TABLE 6

CALCULATION OF SURFACING COST PRICE TRENDS VS HIGHWAY COST TRENDS[a]

| Year | Index No. | Period | n | Ratio | $(1+i)^n$ | i(%) |
|---|---|---|---|---|---|---|
| | | | (a) Composite Highway Cost Index | | | |
| 1929 | 55.0 | 1929-1963 | 34 | 101.7/ 55.0 | 1.85 | 1.8 |
| 1940 | 42.8 | 1940-1963 | 23 | 101.7/ 42.8 | 2.38 | 3.9 |
| 1950 | 78.3 | 1950-1963 | 13 | 101.7/ 78.3 | 1.30 | 2.0 |
| 1957 | 103.1 | 1940-1957 | 17 | 103.1/ 42.8 | 2.41 | 5.3 |
| 1963 | 101.7 | 1957-1963 | 6 | (103.1/101.7) | (1.015) | -0.3 |
| | | | (b) Portland Cement Concrete Index | | | |
| 1929 | 51.1 | 1929-1963 | 34 | 100.3/ 51.1 | 1.97 | 2.0 |
| 1940 | 41.9 | 1940-1963 | 23 | 100.3/ 41.9 | 2.40 | 4.0 |
| 1950 | 82.7 | 1950-1963 | 13 | 100.3/ 82.7 | 1.21 | 1.5 |
| 1957 | 99.2 | 1940-1957 | 17 | 99.2/ 41.9 | 2.36 | 5.2 |
| 1963 | 100.3 | 1957-1963 | 6 | 100.3/ 99.2 | 1.012 | +0.2 |
| | | | (c) Bituminous Concrete Index | | | |
| 1929 | - | - | - | - | - | - |
| 1940 | - | - | - | - | - | - |
| 1950 | 88.5 | 1950-1963 | 13 | 95.6/ 88.5 | 1.08 | 0.6 |
| 1957 | 101.4 | - | - | - | - | - |
| 1963 | 95.6 | 1957-1963 | 6 | (101.4/ 95.6) | (1.06) | -1.0 |

[a]Cost data from U. S. Bureau of Public Roads as given in Table 3.

increase at the long-term rate of 2.0 percent, the differential rate of change is zero percent per year for highway costs, because the rate of inflation and the rate of highway cost increases are equal. If the highway cost trend since 1957 continues, the differential decrease in prices would be approximately 2 percent per year.

The indiscriminate use of composite indexes can lead to serious errors. For example, when performing an economic comparison of pavement types, it might be wholly inappropriate to use a composite highway cost index. Instead, surfacing cost indexes should be used to calculate price trends. It may be that surfacing cost trends parallel the composite highway cost trend, but this should be investigated.

Table 6 presents an analysis of composite highway cost and surfacing cost trends using data from the U. S. Bureau of Public Roads. Unfortunately, surfacing cost data for bituminous concrete were not collected before 1950 and long-term price trends could not be derived for this material. Nevertheless, recent trends can be observed for bituminous concrete surfacing and long-term trends can be ascertained for portland cement concrete surfacing.

A comparison of the portland cement price trends with composite highway costs shows that they have not differed by more than 0.5 percent for any given time period. However, costs of bituminous concrete have recently been changing as much as 1.5 percent less per year than the composite highway costs. This clearly demonstrates the necessity of examining the cost trends of the major elements of highways.

Table 6 also shows that costs of portland cement concrete have increased at an annual rate of about 2 percent since 1929 but have remained fairly stable since 1957. Costs of bituminous concrete have risen by only 0.6 percent per year since 1950 and have been decreasing by about 1 percent per year since 1957.

If the future general price trend is assumed to be about 2 percent per year and surfacing cost trends since 1957 continue, it would be appropriate to decrease future portland cement concrete costs by 2 percent and bituminous concrete costs by 3 percent in the economic analysis.

If the future general price trend is assumed to be level and surfacing cost trends since 1957 continue, there would still be no justification for increasing future surfacing costs. Rather, future portland cement concrete costs would remain unchanged and future bituminous concrete costs would decrease by 1 percent per year, relative to the general price trend.

A word of caution is in order; the Bureau of Public Roads Indexes are nationwide figures and should not be used where accurate state or local data may give better price trends. Nevertheless, a compilation by the Engineering News-Record reveals that of 10 states reporting highway cost trends, only two had price changes greater than those indicated by U. S. Bureau of Public Roads Indexes (9, p. 98). Moreover, a look at surfacing costs in California bears out the same conclusions (12). The 1963 costs of portland cement concrete pavement and asphalt concrete pavement did not change appreciably compared to 1956-1957 levels. These cost trends are remarkably close to the nationwide figures published by the U. S. Bureau of Public Roads. If these cost trends continue in California and the general price level remains constant, it would be erroneous to increase future surfacing costs in economy studies as advocated elsewhere (13).

## TREATMENT OF PRICE CHANGES IN ECONOMY STUDIES

Most of the recommendations for the treatment of inflation and differential price changes have come from those concerned with Federal water resources investments. These recommendations should apply equally well to Federal highway investments. We shall proceed by examining Federal water resources agency practice, the recommendations of certain economists, and the practice of private enterprise.

### U. S. Department of Agriculture

In an article appearing in the 1958 Yearbook of Agriculture, the policy of the Department of Agriculture with regard to dealing with price changes for land and water resources development is expressed as follows:

> Because supply and demand determine prices, each requires careful analysis when one tries to derive estimates of prices. Expected future prices, rather than current or historical prices, should be used in the evaluation of project benefits. (14, p. 546)

That they are writing of differential price changes in this statement rather than general price trends is shown by an ensuing paragraph:

> Inflationary and deflationary trends should be removed from the analysis of commodity and service prices so that a constant dollar may be used in comparing project costs and benefits. (14, p. 547)

The same treatment of price trends is also recommended in a guide for the Soil Conservation Service to be used in performing economic analyses of watershed protection and flood prevention projects (15).

### U. S. Bureau of Reclamation

The Bureau has given the following instructions to those engaged in economic investigations:

> Price levels for project evaluation should reflect the exchange values of the goods and services involved, consistent with assumed general price levels for the period of analysis.

> Long-term projected prices reflect relatively high national employment, increasing population, continued economic growth, and a stable general price level, with production and requirements in balance under competitive conditions. Deferred or recurring benefits and costs should be measured at average long-term prices representative of the period of analysis. Current prices should be used for investment costs to be incurred in the near future. When benefits are based on alternative cost, the price level should be that expected to prevail at the time when the costs would occur. (16)

U. S. Army Corps of Engineers

Federal water resources agencies have not been in agreement on this matter, however, and the Corps of Engineers has stated:

> unless and until research and experience produce techniques for forecasting future prices in such a way as to engender confidence that the price projections are sound and consistent, prices current at the time of the study will generally be assumed for costs and benefits. Price experience to date applicable to each situation will be considered. Possible future changes in prices will be used only in special situations warranting a departure from use of current prices. (17)

Senate Document 97

The most recent Federal statement on recommended price levels is included in Senate Document 97, which is an agreement reached on project evaluation standards for water resources development by the Secretaries of Agriculture, Interior, Army, and Health, Education and Welfare:

> The prices used for project evaluation should reflect the exchange values expected to prevail at the time costs are incurred and benefits accrued. Estimates of initial project costs should be based on price relationships prevailing at the time of the analysis. Estimates of benefits and deferred costs should be made on the basis of projected normal price relationships expected with a stabilized general price level and under relatively full employment conditions for the economy. Pending development of mutually acceptable long-term price projections of this type, normalized current price relationships may be used in estimating deferred project effects. (18)

Recommendations of Economists

A number of economists outside of government have written on the subject of the use of price trends in economy studies and have been unanimous in their rejection of the inclusion of an inflation rate in the analysis. Some, however, would include differential price trends.

McKean suggests that current price levels be used because:

> there seems to be no good reason for having the government bet on inflation in connection with water-resource projects, since a bet on inflation, even if it seems likely to be a good wager, makes projects spuriously attractive to the nation. Furthermore, it is a bet by government on its own failure to win its struggle for stability—a type of wagering that is frowned upon in most contests. (19)

Eckstein also argues for the assumption of stable future prices when making economy studies of water resources projects:

> an assumption of steady inflation is unacceptable because it would mean that government investments would be justified by price increases which, at least in part, would be caused by the program itself; it would be politically immoral for the federal government to operate any expenditure program on the assumption that it will finally be justified by the government's failure to maintain the value of the currency. (20)

Furthermore, Hirshliefer and others, state that:

> it would be a crude error to inflate future revenues in propotion to the price levels expected to govern in those periods and then to weigh these inflated revenues against costs measured in today's dollars. The entire comparison of costs and revenues should be calculated using dollars of constant purchasing power of some convenient period, usually the present period. (4)

A panel of consultants to the U. S. Bureau of the Budget on evaluation standards for the development of land and water resources advised that "In no case should trends in the general price level be incorporated into the economic analysis of projects." Only when values of goods and services associated with a project are expected to rise relative to the general price level do they recommend an escalation of prices and then for only 10 yr in the future because of uncertainty. However, they warn that this advice is not appropriate if sites, such as open spaces for recreational purposes, were preempted for other purposes. In this case, price projections beyond 10 yr might be justified (21).

Private Enterprise

The American Telephone and Telegraph Co. has adopted the following convention with regard to inflation:

> Neither short nor long rates of inflation are predictable with any degree of certainty. To compound the problem, the effects of inflation on individual items of a study become less predictable especially in light of probable technological advances.
>
> While a rigorous evaluation of inflation in studies is not recommended the engineer should consider the possible effects of inflationary trends as a part of uncertainty analysis. If, for example one of two plans has a large labor component compared to the other, it is certainly in order for the engineer to ask, "Which plan is more sensitive to inflation? At what rate, and over what period, would inflation cause the decision to shift to another plant?" (22)

## SUMMARY OF OPINIONS

Most of the sources cited agree that trends in the general price level should not be included in an economic analysis from the national viewpoint. But disagreement is evident when considering relative price changes.

In the first case, that of general price level changes, it is agreed that an inflation rate should not be included because: (a) future dollars to pay for future expenses will likewise be inflated and there is no net change; (b) it is not known what the rate of inflation will be in the future, if any; (c) inflated future benefits may make an uneconomical project appear justified, whereas if constant prices were used it would not be. The resources used and the services rendered are the same in each case; and (d) it would be irresponsible on the Federal level to include an inflation rate when the government is committed to a price stabilization policy. Moreover, Federal expenditures in time of inflation may contribute to inflation.

With regard to relative price levels, the argument seems to rest primarily on our ability to forecast the general price trend and relative price trends of project goods and services. The government's commitment to stabilization policies, the difficulty in measuring price changes, and improved technology make it exceedingly difficult to predict either general or relative price changes. Nevertheless, there may be instances where differential changes are evident and these should be included in a sensitivity analysis. Probably the most common instance is that of changes in land prices. The situation often exists where land prices have been increasing at a greater rate than general price levels, and it is expected that the trend will continue. Projections of land prices must then be made and used (with inflation removed) in the economy study. This, however, is an extremely complex matter and beyond the scope of this paper. It is a subject in need of intensive research.

## THE QUESTION OF VIEWPOINT

The foregoing opinions deal primarily with the national viewpoint. When the viewpoint is nationwide, an estimated general trend in prices should not be included in the economy study. Nevertheless, in principle, expected differential price changes ought to be considered. In contrast, from the state or local viewpoint, a condition may call for the use of the general price trend in the analysis. This occurs when creditors fail to increase the interest rate on borrowed funds in anticipation of inflation. If creditors raise the interest rate on borrowed funds to account for expected inflation, no advantage accrues to the state or local area. (Whether or not interest rates reflect anticipated inflation is a matter of controversy, in need of further investigation.) The reasons for the difference in viewpoint were discussed previously.

## EFFECT OF INCLUDING PRICE CHANGES IN ECONOMY STUDIES

Here we are concerned with the effect of increasing future costs and/or benefits in economy studies. Whether or not any price changes should be included is discussed later.

The use of rates to increase future costs and/or benefits in economy studies will tend to promote greater capital outlays and more capital-intensive projects than would otherwise occur.

The first situation can arise if future benefits alone are increased. This practice will cause projects to be accepted which would be rejected if the benefits were not inflated. Moreover, the practice could have adverse effects when allocating funds among departments if some departments choose to inflate benefits and others do not.

The second situation happens when future capital costs are increased, causing stage construction to appear less desirable than would otherwise be the case. Moreover, longer lived facilities will be favored over shorter lived ones. Thus, a bias occurs which compounds the problem of uncertainty since capital-intensive projects usually allow less flexibility when changes in forecasts arise. This situation is typical of that faced by highway engineers trying to determine which pavement type to use or whether to build highways in stages. For example, increasing future costs might cause a decision to be shifted from asphalt concrete pavement to portland cement concrete pavement. It can also result in the selection of single-stage highway construction when multi-stage highway construction would otherwise appear more economical.

The higher the minimum attractive rate of return (i.e., the interest rate) used in an economic analysis, the less sensitive a decision among alternatives will be to the evaluation of benefits and costs occurring some years in the future. This point was made by Fish over 40 yr ago (23). Therefore, the issue of treatment of prospective price changes is more important in those highways agencies requiring rates of return of 0 to 3 percent to justify investments and less important in agencies requiring, say, 6 percent or more.

## PRICE CHANGES AND FINANCIAL ANALYSIS

General price trends as well as relative price changes are properly a part of the financial analysis of highway programs. Consider the situation where highway costs

are increasing at the same rate as income. For a pay-as-you-go program, the burden on the public of spending more dollars in the future for the same physical amount of highway construction is not increased if inflation occurs. Nevertheless, institutional problems are created in getting the required additional funds because user taxes must be increased. When ad valorem taxes are used, the increase in assessed valuation automatically brings in the necessary additional funds whenever assessors regularly adjust their assessments to recognize inflation.

However, when highway projects are funded by bonds rather than on a pay-as-you-go basis, consideration must be given to inflation; otherwise funds set aside or authorized now to finance future construction may not be sufficient because of price increases. For example, a bond issue of $70,000,000 (based on current prices) to finance a trafficways program may not be adequate when facilities are built in stages. Yet a proper economic analysis may have shown staging to be the more economical solution. To be able to finance the staged project, an allowance for inflation would have to be included in the original bond issue or a future bond authorization would be necessary.

## CONCLUSIONS

From the foregoing analysis we observe that it is difficult to measure past inflation rates since no single index is completely satisfactory. Nevertheless an approximate figure of 2 percent per year compounded is probably a reasonable figure for the long-term rate in the United States. The magnitude of future inflation cannot be known with any certainty.

The body of professional opinion is against including an inflation rate in engineering economy studies made from a national viewpoint. The main reasons are

1. Difficulties are inherent in forecasting;
2. The Federal Government is committed to price stabilization;
3. Federal programs, justified in part by inflating benefits, may contribute to inflation;
4. The gains received by debtors are offset by losses to creditors.
5. Future dollars to pay for future expenses will likewise be inflated and there is no net change; and
6. A bias toward capital-intensive and long-lived projects results, making adaptations to future changes more costly than otherwise.

In principle, expected differential price changes should be included in an economy study. Thus, if the inflation rate is expected to be 2 percent per year and estimated project costs are expected to increase at 3 percent per year, the differential rate for increasing project costs would be 1 percent per year. It is likely that the differential rates will vary for each of the cost components of the project and these should be computed separately for the major components such as land.

From the state or local viewpoint, it is appropriate to use the expected general price trend since transfers can be beneficial from these viewpoints, provided inflation is not anticipated by those persons and institutions lending funds.

The indiscriminate use of indexes of price changes to situations where they do not apply can cause serious distortions in the decision-making process. Nationwide composite cost indexes should not be used when state or local indexes are available. Neither should composite indexes be used if component indexes are available. The use of the Engineering News-Record Construction Cost Index may be entirely appropriate in some instances but wholly incorrect in others. The cost of each important item should be carefully examined.

## RECOMMENDATIONS

In view of the findings of this paper there is no justification for including inflation rates in highway economy studies when taking the national viewpoint. Even from the local viewpoint, such a practice is hard to justify because of the difficulties in predicting future inflation rates.

Although differential rates should, in principle, be included in highway economy studies, there are good reasons for using current prices to evaluate costs and benefits.

1. It is extremely difficult to predict relative price changes for most items in highway economy studies.
2. Over the long term, the average highway cost trend and the general price trend have been quite parallel, which indicates a zero differential rate.
3. Future deviations from current prices are not as serious as might appear because the usual purpose of the analysis is to compare alternatives. Moreover, discounting further reduces the effect of actual costs deviating from current prices.

It is, therefore, our recommendation that, as a general rule, current prices be used to evaluate benefits and costs in highway economy studies, regardless of viewpoint. When there is overwhelming evidence that certain inputs or outputs such as land are expected to experience significant price changes relative to the general price level, the engineering economy study might well include a sensitivity analysis. At the point where the decision is reversed, the prices can be carefully examined to determine if there is a high probability that they will prevail.

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## *Discussion*

A. C. ESTEP, Engineer of Design, California Division of Highways—We agree with the general conclusions of this paper, and concur that inflation factors or price trends should not be used in most highway economy studies. However, the California Division of Highways uses a price trend factor in making economic comparisons to be used as one element in the choice of pavement type. Therefore, it may be of interest to present some of our reasons for this practice.

An economic comparison of pavement types is an unusual economic problem in that most of the decisions have already been made. The project has been found a justifiable expenditure, its priority has been tentatively established, the route has been selected, and the number of lanes required has been determined. With the standard of maintenance we endeavor to accomplish, it can be assumed that the benefits to the motorists will be the same with either pavement type. The only economic problem is to determine the pavement type with the lowest long-term cost.

The California method includes initial cost, maintenance, resurfacing cost including engineering and supplemental work occasioned by the resurfacing, and a salvage value of the last resurfacing applied, if necessary, to bring both costs to the chosen comparison period. A price trend factor is applied to compute the estimated cost of future resurfacing. All costs for both types are reduced to present worth using the appropriate factors for 5 percent compound interest. The comparison periods chosen are 20 yr and upward, based on the life of existing portland cement concrete pavements in the vicinity or under comparable conditions. The estimated time when resurfacing of the asphalt pavement will be required is based on experience in the same general area.

The asphalt concrete resurfacing of an asphalt pavement represents a delayed capital expenditure different in time and amount from all other expenditures for either pavement type. Its entire cost represents a difference in cost between the two types, and there are no balancing cost items to counteract any price trend, up or down, that may occur. The problem is how to determine the best estimate of the future cost of an asphalt resurfacing.

Following the same type of reasoning developed by Lee and Grant, we concluded that a price trend factor for asphalt concrete surfacing should be based on an asphalt concrete surfacing cost index. The statement is made by the authors that surfacing cost data were not collected before 1950. California is fortunate in having asphalt pavement cost data going back many years. Starting in 1940, these costs have been used as one of seven items combined to prepare the quarterly reports on the California Highway Construction Cost Index.

Based on the data for this one item for the 20-yr period from 1941 to 1961 and using the compound rate method, the price trend factor was determined to be 2 percent compounded annually. Data from 1961 to the present support the continued use of this rate. The figure for the third quarter of 1964 is somewhat above our 2 percent trend line. The statement that 1963 costs for portland cement concrete pavement and asphalt concrete pavement did not change appreciably compared to 1956-1957 levels is not applicable to our method. This is a price comparison and does not indicate the trend. A comparison of prices for 1962 and 1954 would show a greater increase than indicated by a trend line.

Economic comparisons of future pavement construction alternates are no better than the estimates of cost used, and past cost data are the best evidence available on which to base these estimates. We believe it is more valid to use the long-range price data extrapolated than to assume that there will be no trend in the future.

ROBERT R. LEE and E. L. GRANT, Closure—The reasons given by Mr. Estep as justification for the use in California of a price trend factor are not valid. The California Division of Highways uses a factor of 2 percent compounded annually to inflate surfacing costs, stating that this is the long-term trend expected in the future. We have no argument with this being the cost trend, but we do argue against the 2 percent figure being used in the economic analysis.

First, the long-term general inflation trend has been approximately 2 percent per year compounded annually. This means that the differential rate to be used to inflate surfacing costs would be 0 percent, not 2 percent. Only if surfacing costs are expected to increase 2 percent more than general price trends would future surfacing costs be increased by 2 percent per year. Since this has not been the case, and there is no evidence to suggest this will be the situation in the future, California should use 0 percent, not the 2 percent price trend factor.