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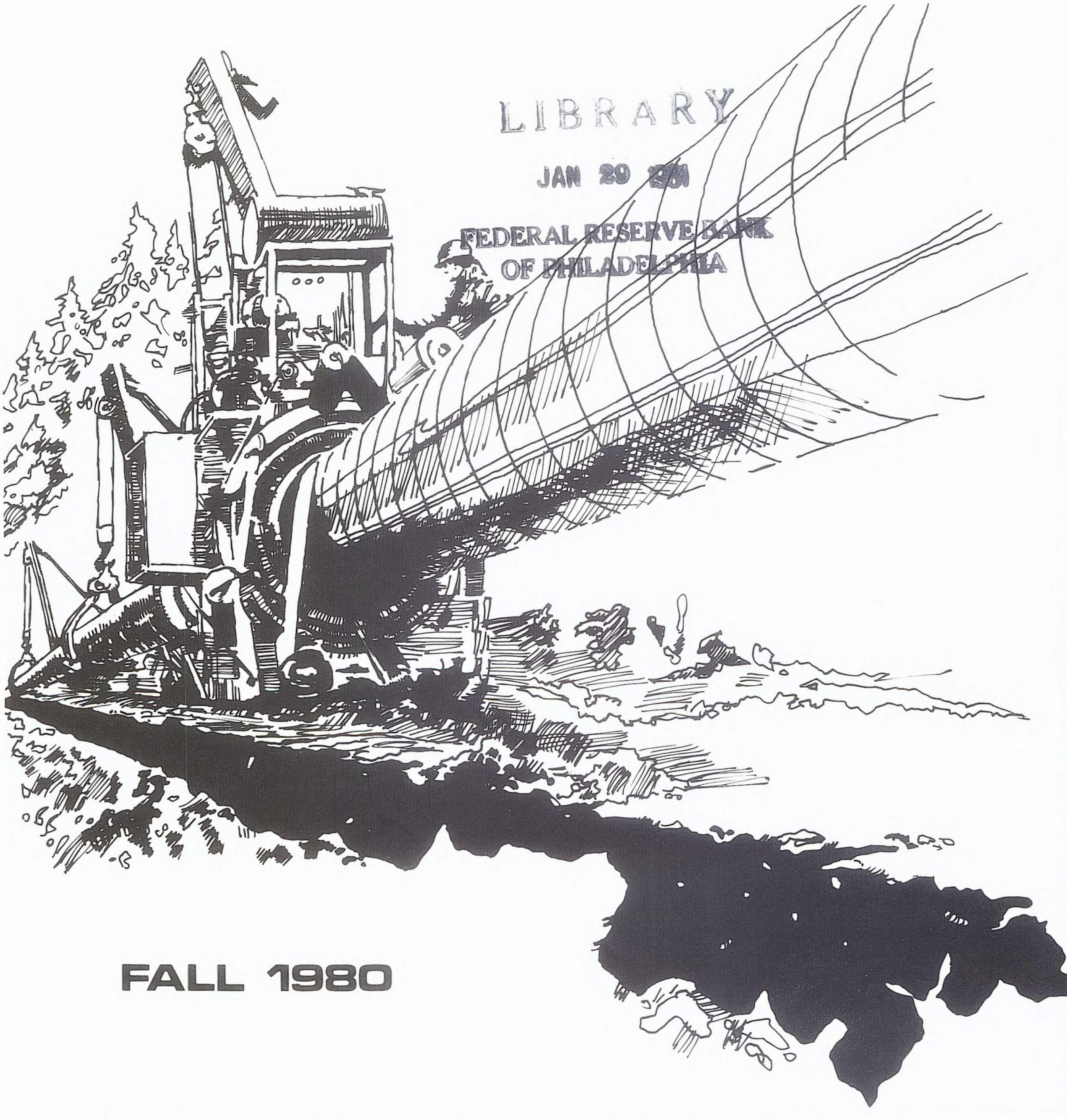

FALL 1980

RESOURCE ALLOCATION-INDUSTRY AND HOUSING

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Resource Allocation—Industry and Housing

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Resource Allocation—Industry and Housing

Public and private policymakers must deal in the 1980's with the problems created by the nation's low investment in capital goods and heavy investment in consumption goods—with all that that means in terms of reduced economic growth. This issue of the *Economic Review* analyzes two aspects of this sectoral resource-allocation theme. The first article discusses the slowdown in U.S. productivity growth as representing a prolonged failure to allocate sufficient resources to capital investment in industry. The second article focuses on policies toward housing and their effect on the behavior of the market under the spur of inflation.

Jack Beebe and Jane Haltmaier note the long-term nature of the slowdown in productivity, with labor productivity rising only about one-third as fast in the 1973-78 period as it did in the 1948-65 period. They also note the serious impact of this slowdown on the nation's living standards—evidenced by the fact that real income per hour would double in 22 years' time at the 1948-65 productivity growth rate, while 58 years would be needed to double real income at the more recent pace of productivity increase.

Studies in the early 1970s attributed much of the deceleration in productivity growth at that time to shifts in employment and output among sectors with different levels of labor efficiency. Indeed, the early postwar shift of workers out of the low-productivity farm sector to higher productivity sectors initially boosted aggregate U.S. productivity growth, but this positive effect waned as the farm share of total employment dropped steeply in recent decades.

Beebe's and Haltmaier's results show that intersectoral labor and output shifts accounted for only a small part of the recent slowdown in labor productivity. "Between the 1948-65 and 1973-78 periods, intersectoral shifts contributed only 0.3 percentage points of the 2.0-percentage-point deceleration in aggregate labor-productivity growth. Moreover, sector-specific declines became evident in nine of twelve industrial sectors, indicating the widespread nature of the productivity slowdown."

The authors show that reduced capital deepening—slower growth of the capital-labor ratios within sectors—was an important factor in the labor-productivity slowdown, accounting for one-third to one-half of the deceleration. On an industry level, this factor was especially important in agriculture, mining, and the large "commercial and other" sector. They also show that the slowdown was not limited to labor productivity, but was evident also in total factor productivity (involving both labor and capital inputs).

Beebe and Haltmaier cite a number of factors that might have contributed to the slowdown in capital investment and hence in productivity. These factors included economic uncertainties, inflation, reduced output growth, tax laws, and government regulations. Consequently, they conclude that "an appropriate policy response would call for a re-examination of governmental policies and other factors that affect capital formation."

With relatively fewer resources allocated recently to industrial capital investment, the question arises regarding the possible overallocation of resources to other sectors. Randall Pozdena suggests that the beneficiary, to some extent, may have been the housing sector. He explores a paradox: housing prices rose relative to most other prices in the economy between 1970 and 1980, prompting officials to argue that housing had become "unaffordable" and that more resources should be directed into the industry, and yet the consumption of housing services continued to rise during this period. Not only did the number of housing units rise faster than the population, but the quality of housing services also rose in terms of floor area and amenities.

In attempting to unravel the paradox, Pozdena argues, "Inflation has been at the root of many of the industry's problems—but this does not mean that inflation has caused a crisis in the form of unaffordable housing or unavailability of rental housing." He argues that housing costs, when properly measured, have fallen relative to other prices despite the rise in housing prices. The widely observed trend away from rental housing, including the conversion of rental housing to owner-occupancy status, meanwhile represents a natural consequence of households' attempts to cope with the combined impact of inflation and tax regulation.

Moreover, he argues that the combination of inflation and special tax treatment tends to alter relative rates of return between housing and other assets, and not simply within housing itself. "Thus, capital that otherwise would have flowed into industrial uses frequently has been attracted to housing instead. Thus the true 'crisis' may be that too much—rather than too little—housing is produced and consumed in our economy."

Pozdena adds that further inflationary distortions occur because of the way that housing is treated in the consumer-price index, which confuses the costs of purchasing housing assets with various costs involved in holding such assets over time. Had an alternative "rental equivalence" measure of housing costs been used in the consumer price index, the index probably would have stood more than eight percent below its reported value in 1979. Thus he concludes, "Considering the myriad public and private programs and contracts which use the CPI as an inflation index, such an overstatement itself has introduced inflation-related distortions into the economy."

An Intersectoral Analysis of the Secular Productivity Slowdown

Jack Beebe and Jane Haltmaier*

Economists and policymakers have become increasingly concerned in recent years about the slowdown in U.S. productivity. Productivity has always exhibited a strong cyclical movement in line with changes in business conditions, but analysts today are less concerned with these quarter-to-quarter gyrations than with the *secular* (noncyclical) trend. For the private economy, the annual rate of increase in labor productivity (output per hour) averaged 3.2 percent for the 1948-65 period, but slowed to 2.3 percent in the 1965-73 period and then to only 1.2 percent in the 1973-78 period. The rate of increase in total factor productivity (output per weighted unit of capital and labor input) exhibited a similar slowdown—from an annual rate of 1.3 percent in the first period to 0.7 percent and 0.4 percent in the last two periods, respectively. Since 1978, the figures have been much worse, largely reflecting adverse cyclical factors in addition to this secular weakness.

Concern over the secular trend of productivity stems from its role as the key determinant of the nation's material standard of living. For example, at a 3.2-percent annual growth rate (the 1948-65 average), real income per hour would double in only 22 years, whereas at a 1.2-percent rate (the 1973-78 average), 58 years would be required. Moreover, the rate of labor-productivity increase is the major determinant of the difference between wage and price inflation. With a 3.2-percent rate of increase in labor productivity, annual wage inflation of 10.0 percent would translate roughly into price inflation of 6.8 percent. With a 1.2-percent productivity increase, however, the same rate of wage inflation would translate into price inflation of 8.8 percent. Labor-productivity growth therefore is clearly central to the political issues that arise when the gap narrows between wage and price inflation.

What factors underlie the secular deterioration in productivity growth? A decade ago, many studies attributed the deceleration in productivity growth to shifts in employment and output among sectors with different levels of labor efficiency.[1] In particular, the early-postwar shift of workers out of the low-productivity farm sector to higher-productivity sectors initially boosted aggregate U.S. productivity growth, but this positive effect waned as the farm share of total employment declined from 18 percent in 1948 to 5 percent in the 1970s.

The productivity slowdown would not be a major public-policy issue if this were all that was involved, because basic structural changes in the economy cannot be manipulated easily by government policy.[2] Even if they could be, generally it would not be in the public interest to do so, for such structural changes tend to reflect the public's basic preferences to spend their incomes and seek employment in ways that increase society's general welfare.

Some studies suggest that sectoral shifts are still of overriding importance,[3] but the evidence presented in this paper points strongly to the conclusion that such shifts have accounted for only a small portion of the slowdown in aggregate labor-productivity growth. This conclusion suggests the existence of other causal factors, such as a general slowdown in capital deepening—resulting perhaps from the

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combined effects of economic uncertainties, reduced output growth, inflation, tax laws, and regulations. In this case, then, an appropriate policy response would call for a re-examination of governmental policies and other factors that affect capital formation.

Many recent studies have approached the productivity problem in an aggregate context. This paper, in contrast, presents a disaggregated analysis of productivity in the private domestic U.S. economy, concentrating on the questions of intersectoral shifts and capital deepening.[4] We first present a twelve-sector disaggregation of labor productivity, and then a seven-sector analysis of capital deepening and total factor productivity.

Our technique advances the state of the art by providing close approximations for the relationship between aggregate and sectoral labor-productivity changes. We decompose aggregate labor-productivity increase into "rate" and "level" effects: the rate effect refers to the portion attributable to productivity growth within sectors, and the level effect refers to the portion attributable to shifts in employment and output across sectors. We then estimate the important role of capital deepening (i.e., increases in the capital-labor ratio) within seven major sectors, and examine in detail the bias inherent in using aggregate as opposed to sectoral data. Although we link a deceleration in capital deepening to the productivity slowdown, we do not investigate the underlying causes of retarded capital deepening.[5]

The results show that intersectoral labor and output shifts accounted for only a small amount of the slowdown in aggregate labor productivity. Between the 1948-65 and 1973-78 periods, intersectoral shifts contributed only 0.3 percentage points of the 2.0-percentage-point deceleration in aggregate labor-productivity growth. Moreover, sector-specific declines became evident in nine of twelve industrial sectors, indicating the widespread nature of the productivity slowdown.

Slower growth of the capital-labor ratios within sectors was found to be an important factor in the labor-productivity slowdown, accounting for almost half of the deceleration. On an industry level, this factor was particularly important in agriculture, mining, and the large "commercial and other" sector. The results of this study underscore the importance of disaggregation, since the aggregate approach tends to attribute too little of the labor-productivity slowdown to slower capital deepening.

Finally, we show that the productivity slowdown was not limited to labor productivity, but was evident also in total factor productivity (both labor and capital). The secular rate of increase in that more inclusive category declined from 1.3 percent per annum over the 1948-65 period to 0.7 percent and 0.4 percent over the 1965-73 and 1973-78 periods, respectively. The deceleration was broad-based, with acceleration evident in only two sectors— communication and commercial and other.

In Section I, we analyze the rate and level effects of labor productivity in a disaggregated framework. In Section II, we analyze total factor productivity, the role of the capital-labor ratio, and measures of aggregation bias. Finally, we present the conclusions and policy implications of the paper.

I. Sectoral Decomposition of Labor Productivity Change

Published labor productivity data are calculated with the use of direct aggregation: outputs are added across sectors, labor inputs are also summed, and total output is then divided by total labor input to arrive at a calculated aggregate level of labor productivity.[6] In a multisector model that employs directly aggregated data, aggregate labor productivity is affected over time by productivity change within each sector and by the shift of output and employment among sectors with different levels of productivity. The following formulation, which is derived in the note on page 24, decomposes aggregate productivity change into rate, level and interaction effects.[7]

$$\frac{\Delta P}{P} = \Sigma q_i \frac{\Delta P_i}{P_i} + \Sigma q_i \frac{\Delta l_i}{l_i} + \Sigma q_i \frac{\Delta P_i}{P_i} \frac{\Delta l_i}{l_i} \quad (1)$$

where

P = aggregate output per hour (labor productivity)

P_i = output per hour in the i-th sector

q_i = real output share of the i-th sector

l_i = share of hours employed in the i-th sector

$\frac{\Delta P}{P}$ = percentage change in productivity over the discrete time period.

The rate effect is the part of aggregate productivity growth that comes about as a result of changes in productivity *within* sectors. In the context of labor productivity, it is the amount of change that would have occurred over time had each sector's share of total employment remained constant. In contrast, the level effect is the part of aggregate productivity change that results solely from shifts of labor (and output) *among* sectors—i.e., the amount that would have occurred had productivity levels remained constant within sectors, while labor (and output) shifted among sectors of dif-

Table 1
Labor and Real Product Shares by Industry for Selected Years, 1948–78 (Percent)

	Labor Shares[1]				Real Product Shares[2]			
	1948	1965	1973	1978	1948	1965	1973	1978
Private Domestic Nonresidential Economy	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture[3]	**18.3**	**8.5**	**5.8**	**5.4**	7.0	4.4	3.6	3.4
Mining	1.7	1.1	0.9	1.2	3.0	2.2	1.9	1.8
Construction	5.6	6.3	6.8	6.9	6.6	7.7	5.9	5.3
Nondurable Goods Mfg.	12.6	12.4	11.6	10.8	12.4	12.2	12.4	12.2
Durable Goods Mfg.	14.8	17.3	17.0	16.4	18.0	19.4	18.9	18.1
Transportation	5.7	4.4	4.2	4.1	6.8	5.1	5.1	4.8
Communication	1.2	1.3	1.6	1.5	1.4	2.3	3.2	4.2
Utilities	0.9	1.0	1.0	1.0	1.5	2.6	3.0	2.9
Wholesale Trade	**4.8**	**5.7**	**6.2**	**6.8**	6.6	7.6	8.9	8.9
Retail Trade	**16.9**	**18.0**	**18.2**	**18.2**	12.9	12.4	12.4	12.3
Finance and Insurance	**3.3**	**4.9**	**5.7**	**6.3**	9.7	10.5	10.4	11.1
Services	**13.9**	**18.8**	**20.8**	**21.2**	14.2	13.6	14.3	15.0

[1]Labor data are based on actual hours worked by persons engaged in production, which encompasses full- and part-time workers as well as active proprietors. The data come from the National Income and Product Accounts (NIPA), Table 6.11—except for agriculture (including forestry and fisheries), where data are obtained from household surveys undertaken by the Bureau of the Census for the Bureau of Labor Statistics. (Unpaid household workers engaged in production are included in the agricultural data, but excluded from data of other sectors.)
[2]Output data are actual 1972-dollar gross product (NIPA, Table 6.2). Output in the finance and insurance industry excludes imputed output from owner-occupied farm and nonfarm dwellings (NIPA, Table 8.3, lines 63 and 75).
[3]Includes forestry and fisheries.

Sources: U.S. Department of Commerce and Bureau of Labor Statistics.

fering productivity levels. Finally, over a discrete time period, a (usually very small) interaction effect results from the compounding of simultaneous changes of productivity levels within sectors and labor shares among sectors. (In continuous time, the interaction term drops out.) For each effect, percentage changes within sectors are weighted by real output shares to arrive at sectoral contributions to the aggregate. An individual sector's contributions to the aggregate rate, level, and interaction effects are simply its contributions within the respective summations.[8]

The rate effect has more than empirical relevance. It represents an aggregate productivity index free of "aggregation bias" caused by shifts among sectors of differing productivity levels. For some time, economists have used the Divisia productivity index (named after the French mathematician) largely because of its freedom from such bias. In Appendix A, the rate effect under direct aggregation and the Divisia index are shown to be close approximations.

Empirical Results

Table 1 shows labor and real product shares within the private domestic nonresidential economy.[9] The most notable labor shifts in the postwar period have been the net decline in the agricultural sector and the net increase in the service-related sectors—comprising wholesale and retail trade, finance and insurance, and services (highlighted in the table). Changes in labor shares in other sectors have been comparatively modest. Meanwhile, shifts in real-output shares generally have been smaller but in the same direction as shifts in labor shares.

Table 2 shows the secular annual rates of increase in labor productivity for the total and for twelve industrial sectors over subperiods within the 1948-78 span.[10] The slowdown in both the 1965-73 and 1973-78 periods was widespread throughout the economy. Only three sectors—communication, finance and insurance, and services—experienced an acceleration in the rate of productivity advance in the most recent period, and only in communication and services was the most recent rate above that in the 1948-65 period.[11] All other sectors showed a marked deceleration—and mining, construction and wholesale trade experienced an actual decline in labor productivity. The decline in mining has often been attributed to new safety regulations and practices (the value of which is not included in measured output), and to the intensive use of marginal facilities in response to higher energy prices. The declines in construction and wholesale trade remain a puzzle to productivity analysts.[12]

There appears to be no direct correlation between the magnitude of measurement error and magnitude of productivity slowdown. For example, productivity change may be subject to considerable measurement error in con-

Table 2
Secular Productivity Change Between Peak Years by Industry[1]
(Annual Rates of Increase)

	1948–65	1965–73	1973–78
Private Domestic Nonresidential Economy	3.2	2.3	1.2
Agriculture	5.1	4.6	1.6
Mining	4.3	1.9	−4.8
Construction	3.4	−2.1	−1.1
Nondurable Goods Manufacturing	3.3	3.3	2.3
Durable Goods Manufacturing	2.8	2.2	1.1
Transportation	3.1	2.9	0.8
Communication	5.4	4.6	7.1
Utilities	6.3	3.5	0.7
Wholesale Trade	3.0	3.4	−0.6
Retail Trade	2.7	2.1	1.1
Finance and Insurance	1.3	0.1	0.8
Services	1.2	1.7	1.8

[1]Compound annual growth rates calculated between the first and last year of each subperiod.

Sources: See Table 1.

struction, trade, finance and insurance, and services. However, the first two sectors have shown large decelerations in productivity growth, whereas the other two have not (footnotes 11 and 12).

Table 3 shows the growth rate of aggregate productivity decomposed into rate, level, and interaction effects. From this evidence, the productivity slowdown can be attributed largely to a slowdown in the rates of productivity growth *within* sectors rather than to shifts in employment *across* sectors. The rate of aggregate productivity growth declined 0.98 percentage points between the 1948-65 and 1965-73 periods (from 3.24 percent to 2.26 percent). Of this decline, 0.77 percentage point was accounted for by the change in the rate effect, and only 0.20 percentage point by the change in the level effect.

Between the 1965-73 and 1973-78 periods the story was similar, with the change in the rate effect accounting for 0.91 percentage point of the 1.02-percentage-point decline in the rate of aggregate productivity growth. In short, over the three subperiods, the rate effect—i.e., slowdown in productivity advance within sectors—accounted for 1.68 percentage points of the 2.00-percentage-point decline in aggregate productivity advance.[13]

It is important to consider both the respective sizes of the two effects within periods and their changes from period to period. For example, the level effect—the shifting of labor among sectors of differing productivity levels—added 0.43 percentage point to the aggregate-productivity growth rate during the 1948-65 period. But this positive boost receded to 0.23 and 0.15 percentage points per year in the two later periods, respectively. Despite its contribution to the productivity slowdown, the level effect nevertheless was still positive.

Table 4 shows the contributions of each sector to the total rate effect.[14] The 1948-65 period was dominated by the large positive contribu-

Table 3
Decomposition of Labor Productivity Change Into Rate, Level, and Interaction Effects (Annual Rates of Increase)

	1948–65	1965–73	1973–78
Private Domestic Nonresidential Economy	3.24	2.26	1.24
Percentage Point Change	—	−0.98	−1.02
Rate Effect	2.82	2.05	1.14
Percentage Point Change	—	−0.77	−0.91
Level Effect	0.43	0.23	0.15
Percentage Point Change	—	−0.20	−0.08
Interaction	−0.01	−0.02	−0.05

Sources: See Table 1. Calculated using equation (1), iterated annually.

Table 4
Decomposition of Rate Effect by Industry (Percentage Contributions to Annual Rates of Change)

	1948–65	1965–73	1973–78
Private Domestic Nonresidential Economy	2.82	2.05	1.14
Agriculture	.31	.21	.06
Mining	.11	0.4	−.09
Construction	.25	−.14	−.06
Nondurable Goods Manufacturing	.40	.41	.28
Durable Goods Manufacturing	.50	.40	.18
Transportation	.17	.14	.04
Communication	.10	.13	.26
Utilities	.13	.10	.02
Wholesale Trade	.22	.27	−.04
Retail Trade	.34	.26	.13
Finance and Insurance	.14	.01	.09
Services	.16	.23	.28

Sources: Table 3 and the individual rate effects in equation (1), iterated annually.

tions of agriculture, construction, manufacturing, and trade. The sizable contribution of the agricultural sector came mostly from its rapid 5.1-percent annual productivity increase (Table 2), as its real output share in 1948 was only 7.0 percent (Table 1). But agriculture's contribution to the rate effect was almost nil in the most recent period, with a decline in its productivity growth rate to 1.6 percent and a decline in its real output share to only half of its 1948 level. In mining and construction, the rate effects declined sharply, turning negative with declines in the levels of labor productivity. In the two manufacturing and two trade sectors, the rate effects were large in the early period, but declined significantly by the most recent period (turning negative for wholesale trade). The diminution in these rate effects can be attributed almost entirely to slower rates of labor productivity advance within sectors (Table 2), because of the rough constancy of real output shares (Table 1).

The rate contribution accelerated in the 1973-78 span only in communication, services, and finance and insurance—and in the latter sector, it still fell below its 1948-65 annual contribution. The rate of labor-productivity increase accelerated sharply in communication (largely the telephone industry) while the sector's share of real product also rose.

To summarize, the slowdown in aggregate labor-productivity growth was almost wholly attributable to productivity slowdowns within the twelve industrial sectors. The level effect, in contrast, accounted for only 0.3 percentage point of the 2.0-percentage-point deceleration in aggregate labor-productivity growth between the 1948-65 and 1973-78 periods. The slowdown was spread widely across nine of the twelve sectors, as demonstrated first by the slowdown within sectors (Table 2), and also by the individual contributions to the rate effect (Table 4), which take into account both the intrasectoral slowdowns and their relative weights in the aggregate index.

II. Capital Deepening and Total Factor Productivity

In this section, we measure total factor productivity—the rate of change of output per unit of combined input of labor and capital. Through the specification and estimation of aggregate and disaggregated production functions, we estimate the slowdown in total factor productivity for the aggregate economy and for seven major sectors, and compare the resultant trends to those of labor productivity. We also estimate the role played by capital deepening (rise in the capital-labor ratio) in labor productivity growth, through a comparison of aggregate and disaggregated methods of analysis.

Capital deepening affects labor productivity differently from total factor productivity. It can affect labor-productivity growth in at least two ways. First, given a positive marginal product of each factor of production, an increase in the amount of capital used by the same number of workers will result in a larger amount of output produced per worker. Second, given the embodiment of technological improvements in new plant and equipment, capital growth should provide a further boost to labor productivity. If both effects are important, capital formation will have a magnified impact on labor-productivity growth over time.

Table 5 shows a slowdown in growth in the aggregate and sectoral capital-labor ratios[15] over time, with the exceptions of manufacturing and utilities. More importantly, slower growth in the capital-labor ratios was not simply the result of slower growth in the capital stock. Aggregate capital and labor growth both accelerated in the second period, and labor growth remained relatively high even in the third period. On an aggregate basis, therefore, the slower growth of the capital-labor ratio largely reflected faster labor growth, particularly in the 1965-73 period when capital growth also accelerated. The results for the 1973-78 period were mixed, however, as capital growth decelerated from its 1965-73 rate in all but one sector.

These patterns suggest no evidence of declining investment (except in mining) until the most recent period. However, the rate of new investment failed to keep pace with accelerated labor growth in the 1965-73 period, and has since dropped off precipitously. Norsworthy, Harper, and Kunze suggest that the behavior of capital-labor growth is consistent with an observed acceleration in the price of labor relative to capital between the 1948-65 and 1965-73 periods and a subsequent deceleration between the 1965-73 and 1973-78 periods.[16] Others have attributed this development to the rapid growth of inexperienced workers over time. As the growth rate of inexperienced workers tapers off in the 1980s, capital-labor growth may accelerate once again, although the recent decline in capital formation suggests that such optimism may be unwarranted.

Production Functions

To measure growth of total factor productivity, we must specify a production function linking labor, capital, and output. The output data used here (as in most aggregate productivity studies) are net of intermediate inputs to production, so the production function should properly include only the primary inputs—labor, land (including natural resources), and capital.[17] Actually, we include only labor and capital, because of the weakness of data for land by industry. For simplicity, we use a standard Cobb-Douglas production function with constant returns to scale. However, this type of function requires strict separability[18] and constrains the elasticity of substitution between labor and capital to be constant and equal to one. The function also includes a time trend as a proxy for whatever technical change that is not included in new capital investment:

$$Q = Ae^{rt}K^{\alpha}L^{\beta} \qquad (2)$$

where Q = output,
A = constant term,
r = rate change of disembodied technology or total factor productivity,[19]
t = time trend,

Table 5
Rates of Growth of Capital and Labor by Sector, 1948–78
(Percent)

	1948–65			1965–73			1973–78		
	K/L	K	L	K/L	K	L	K/L	K	L
Private Domestic Nonresidential Economy	2.8	3.3	0.4	2.5	4.0	1.4	1.8	3.1	1.2
Agriculture[1]	7.3	2.8	−4.2	7.3	3.0	−4.0	3.1	2.3	−0.8
Mining	5.4	2.9	−2.3	1.3	1.4	0.0	−4.3	2.2	6.8
Manufacturing	1.9	2.8	0.9	2.3	3.3	1.0	2.4	2.6	0.2
Transportation	1.3	0.2	−1.0	0.4	1.2	0.7	−0.5	0.3	0.8
Communication	6.4	7.6	1.1	5.1	8.8	3.5	5.0	6.0	1.0
Utilities	5.1	6.0	0.9	4.3	6.4	2.0	5.0	5.9	0.9
Commercial and Other[2]	3.2	4.8	1.6	1.9	4.2	2.3	0.4	2.2	1.8

[1]Data for agriculture differ slightly from those in Section I, because forestry and fisheries are excluded from agriculture in this table (and in Section II) to conform to the capital-stock data.
[2]Construction, wholesale and retail trade, finance and insurance, and services.

Sources: Gross capital-stock data are from U.S. Department of Commerce for agriculture (excluding forestry and fisheries) and manufacturing, and from Data Resources, Inc., for other sectors. (These data are calculated by DRI using Department of Commerce service-life assumptions.) See Table 1 for sources of labor data.

K = capital,
L = labor,
α = elasticity of output with respect to capital,
β = elasticity of output with respect to labor.

The constant-returns constraint requires $\alpha + \beta = 1$. Using this constraint and dividing both sides by L, we obtain an expression that relates labor productivity (Q/L) to the capital-labor ratio:

$$P = Ak^{\alpha}e^{rt} \quad k = K/L, P = Q/L \tag{3}$$

In this formulation, α represents the elasticity of labor productivity with respect to the capital-labor ratio (i.e., the percentage change in labor productivity with respect to a one-percent change in the capital-labor ratio). If the rate of growth of total factor productivity is zero (i.e., there is no disembodied technical change and $r = 0$), the rate of growth of labor productivity is simply α times the rate of growth of k, the rate of increase in the capital intensity of production. This can be seen by totally differentiating (3) logarithmically with respect to time.

$$\frac{dP}{P} = rdt + \alpha(dk/k) \tag{4}$$

which can be approximated by

$$\%\Delta P = r + \alpha(\%\Delta k) \tag{5}$$

where r represents the percentage change in total factor productivity (disembodied technical change).

To assess the role of capital formation in the slowdown, it is necessary to determine α. Although this can be done in more than one way,[20] our approach estimates the aggregate and sectoral production functions econometrically, using historical data. The contribution of the capital-labor ratio to labor-productivity growth, with the aggregate method, then is $\alpha\left(\frac{dk}{k}\right)$, where α is estimated from equation (5). Similarly, equation (5) also can be estimated for each of the seven industries, and the contribution of the sectoral capital-labor ratio to sectoral productivity growth is calculated as $\alpha_i\left(\frac{dk_i}{k_i}\right)$.

Before equation (5) can be estimated, terms must be added to account for the effect of the business cycle on labor productivity, and to allow for secular shifts in the growth rate of total factor productivity. To remove business-cycle-related movements, annual changes in the manufacturing capacity-utilization rate were used as a surrogate for business-cycle conditions affecting the aggregate and sectors.[21]

We allowed the value of r to vary over the subperiods of the 1948-78 period, to reflect the probability of a growth slowdown for total factor productivity as well as for labor productivity. Thus we added dummy variables to account for shifts in r among the 1948-65, 1965-73, and 1973-78 periods.[22]

Adding the cyclical and dummy variables to equation (5) produces the following equation for estimating the aggregate and the seven sectors:

$$\%\Delta P = r + \delta_1 d_1 + \delta_2 d_2 + \alpha\%\Delta k + \gamma\%\Delta UCAP + \mu \tag{6}$$

where time subscripts have been suppressed for simplicity. The estimated coefficients have the following interpretations:

r = average annual rate of increase in total factor productivity (disembodied technical change), 1948-65;
δ_1 = shift in the average rate of change of total factor productivity between the 1948-65 and 1965-73 periods;
δ_2 = shift in the average rate of change of total factor productivity between the 1948-65 and 1973-78 periods;
α = elasticity of labor productivity with respect to the capital-labor ratio (and of output with respect to capital);

γ = elasticity of labor productivity with respect to the capacity-utilization rate in manufacturing.

Table 6 shows the estimation results for equation (6) with ordinary least squares, with Cochrane-Orcutt data transformations. Given that the equations are expressed in percentage-change form, the R-squared values are remarkably high, although the standard errors of the regressions reveal considerable variation in the estimated rates of labor-productivity change within sectors.[23]

The coefficients r, $r+\delta_1$, and $r+\delta_2$ give the estimated annual rates of increase of total factor productivity over the three subperiods. As shown in Table 7, they indicate a similar movement in total factor productivity as in labor productivity, in the aggregate and in most sectors. However, there were a few exceptions, especially the "commercial and other" sector, which showed a deceleration in labor-productivity growth but an acceleration in total factor productivity. Apart from data errors, we can interpret the divergence in trends to mean that improvements in efficiency helped improve the productivity of costly capital inputs in this sector. This seems logical, because inexperienced and inexpensive labor inputs tended to increase the fastest in areas such as retail trade and services.

Because aggregate labor-productivity growth is a function of within-sector productivity growth, as well as of input and output shifts among sectors, we can derive an alternative estimate of the effect of capital-intensity growth on aggregate labor-productivity change by combining estimates for individual indus-

Table 6
Regressions of Production Functions for the Private Domestic Nonresidential Economy and Major Sectors, 1948–78

	r	δ_1	δ_2	α	γ	$\bar{R}^2$	S.E.E.	D.W.	ρ
Private Domestic Nonresidential Economy[1]	1.3*	−0.6*	−0.9*	.67**	.37*	.61	1.1	2.05	−.25
	(2.52)	(−1.55)	(−1.77)	(4.21)	(5.48)				(−1.39)
Agriculture[2]	1.2	−0.6	−1.2	.64**	−.32*	.71	2.6	1.92	−.53*
	(1.25)	(−.81)	(−1.14)	(5.60)	(−3.87)				(−3.36)
Mining	2.8*	−1.2	−6.0*	.34**	.16	.68	2.4	1.44	.10
	(2.91)	(−.94)	(−3.16)	(2.45)	(1.68)				(.56)
Manufacturing	1.6*	−0.1	−0.6	.53**	.61*	.23	2.1	1.98	−.25
	(2.19)	(−.12)	(−.64)	(1.99)	(2.79)				(−1.38)
Transportation	2.8*	0.0	−1.7	.19	.36*	.41	2.2	1.87	−.24
	(5.35)	(.04)	(−1.64)	(.85)	(3.00)				(−1.34)
Communication	1.6*	0.0	2.6*	.59**	.14*	.62	1.5	2.25	−.42*
	(2.75)	(−.05)	(4.46)	(7.43)	(2.66)				(−2.47)
Utilities	2.6*	−2.4*	−4.8*	.68**	.09	.44	2.6	1.92	−.43*
	(1.82)	(−2.78)	(−4.94)	(2.54)	(1.12)				(−2.54)
Commercial and Other	0.4	0.1	0.5	.55**	.21*	.36	1.4	2.04	−.03
	(.53)	(.08)	(.59)	(2.84)	(3.81)				(−.15)

Entries in parentheses are t-statistics. * Indicates that the coefficient is significantly different from zero with 90-percent confidence, with the use of a two-tailed test. ** Indicates the same with the use of a one-tailed test.

[1]Capital data were calculated as the sums of component sectors. With the use of the BEA aggregate for gross capital stock in the private domestic nonresidential economy, the estimates were comparable: $r=0.9$; $\delta_1=-0.7$, $\delta_2=-0.7$, $\alpha=.73$, $\gamma=.37$.

[2]Excludes forestry and fisheries.

Source: see text.

tries. To derive the proper weights, we begin by dividing aggregate productivity change into rate and level effects, as shown by the continuous version of equation (1),

$$\underset{}{\frac{dP}{P}} = \underbrace{\Sigma q_i \frac{dP_i}{P_i}}_{\text{(Rate)}} + \underbrace{\Sigma q_i \frac{dl_i}{l_i}}_{\text{(Level)}} \qquad (7)$$

Substituting equation (4) for the individual sectors, we obtain

$$\frac{dP}{P} = \Sigma q_i \left[r_i dt + \alpha_i \frac{dk_i}{k_i} + \frac{dl_i}{l_i} \right] \qquad (8)$$

where $\alpha_i \frac{dk_i}{k_i}$ represents the i-th sector's contribution of growth in capital intensity to its own sector's productivity growth. Therefore, the weights for calculating the sectoral contributions of capital-intensity growth $\left(\alpha_i \frac{dk_i}{k_i}\right)$ to aggregate labor-productivity growth are the output shares, q_i.

We aggregated the industry contributions of capital-intensity growth, using output shares to obtain an estimate of the importance of growth in the disaggregated capital-labor ratios to the slowdown in aggregate productivity growth. Table 8 compares this result with that obtained

Table 8
Contribution of Growth in the Capital-Labor Ratio to Labor Productivity Growth, 1948–78
(Average Annual Rates of Increase)

	1948–65	1965–73	1973–78
Aggregate Productivity	3.24	2.26	1.24
Change from Prior Period	—	−0.98	−1.02
Contribution of K/L			
Aggregate Method[1]	1.88	1.66	1.23
Change from Prior Period	—	−0.22	−0.43
Disaggregated Method[2]	1.70	1.34	0.76
Change from Prior Period	—	−0.36	−0.58

[1] $\alpha dk/k$.
[2] $\Sigma q_i \alpha_i dk_i/k_i$, where the q_i's are the average shares within the subperiods.

Sources: Tables 1, 3, 5, 6, and text.

Table 7
Labor Productivity and Total Factor Productivity, 1948–78
(Annual Growth Rates, in Percent)

	Labor Productivity			Total Factor Productivity		
	1948–65	1965–73	1973–78	1948–65	1965–73	1973–78
Private Domestic Nonresidential Economy	3.2	2.3	1.2	1.3	0.7*	0.4*
Agriculture[1]	5.3	5.1	1.9	1.1	0.5	−0.1
Mining	4.3	1.9	−4.8	2.8	1.6	−3.2*
Manufacturing	3.0	2.6	1.6	1.6	1.5	1.0
Transportation	3.1	2.9	0.8	2.9	2.9	1.2
Communication	5.4	4.6	7.1	1.6	1.6	4.2*
Utilities	6.3	3.5	0.7	2.6	0.2*	−2.2*
Commercial and Other	2.3	1.4	0.9	0.4	0.5	0.9

*Indicates a statistically significant shift in total factor productivity at the 90-percent confidence level, as compared with the rate in the 1948–65 period (see Table 6).

[1]Excludes forestry and fisheries.

Sources: Tables 5 and 6.

from the aggregate estimated equation. Both methods indicate a large role for capital deepening in the growth of labor productivity. However, the aggregate method attributes greater importance to the capital-labor ratio in explaining labor-productivity growth (especially in 1973-78), and less importance in explaining its *slowdown*. Specifically, the aggregate method attributes 0.65 percentage point (one third) of the 2.00-percentage-point slowdown in labor-productivity growth to slower growth of the capital-labor ratio, while the disaggregated method attributes 0.94 percentage point (almost half) to slower growth of the capital-labor ratio.

An explanation of this discrepancy involves an analysis of the estimated α's from equation (6). If the Cobb-Douglas specification of the production function is appropriate, the estimated aggregate α should be roughly .2 to .4, depending on whether one compares it to the profit share or to the nonlabor share of gross private domestic product.[24] However, as Table 6 shows, the estimated α from the aggregate equation is .67. Clark (1978) obtained a similar result of .70 for his aggregate equation using gross capital stock (.48 using net capital stock).[25]

Clark (1978 and 1979) attributed the discrepancy between his estimate of α and capital's income share to the embodiment of technical progress in new capital goods. (Under this condition, new capital investment would produce output greater than that predicted by the percentage change in capital times its income share.) The estimated α from a simple production function such as (5) might well be greater than capital's share if technical progress is introduced largely through its embodiment in new capital goods. However, it would affect the α's of both the aggregate and sectoral equations, and thus would not explain why the aggregate α is above the sectoral estimates.

Aggregation Bias

Comparison of the aggregate α with those of the individual sectors (Table 9) indicates that aggregation bias might be partly responsible for the high value of the aggregate α. All but one of the α_i's from the individual equations are lower than the aggregate, ranging from .19 to .68, with an unweighted average of .50.

Another way to compare the industry α_i's with the estimated α from the aggregate equation is to calculate a weighted average, with the weights based on the following identity:[26]

$$\alpha = \Sigma \alpha_i q_i \left(\frac{dK_i/K_i}{dK/K} \right) \tag{9}$$

The aggregate α in any time period depends on the percentage increases in the capital stock in each sector relative to the total, as well as on the α_i's and q_i's. Although the aggregate α represents the percentage change in output that occurs as a result of a one-percent increase in aggregate capital stock, the size of this output increase will depend in part on the sources of growth in capital stock.[27]

Table 9
Output-Capital Elasticities vs. Nonlabor Income Shares, 1948–78

Industry	α	Standard Error	Nonlabor Income Share
Private Domestic Nonresidential Economy	.67	.16	.43
Agriculture	.64*	.11	.85**
Mining	.34*	.14	.63
Manufacturing	.53	.27	.31
Transportation	.19	.22	.31
Communication	.59	.08	.50
Utilities	.68	.27	.65
Commercial and Other	.55	.19	.45

*Significantly different from the nonlabor income share at the 90-percent confidence level, with the use of a two-tailed test.

**Because of the high proportion of self-employment in farming, this share includes a significant amount of income that should probably be classified as return to labor.

Sources: Table 6, and National Income and Product Accounts, Table 6.1.

Equation (9) provided values of α of .65, .59, and .45 for 1948-65, 1965-73 and 1973-78, respectively. The deceleration primarily reflected a slowing trend in the relative increases in the capital stock of the large "commercial and other" sector over the three periods. These calculations for the aggregate α were all lower than the value of .67 that was estimated using the aggregate equation. Therefore, the aggregate α is biased in its level, since one would expect its estimated value to lie within the bounds of the three calculated values. Also, it is biased in its insensitivity to compositional shifts in output and capital over time, since the sectoral α_i's imply an aggregate α that declines in each subperiod.

As noted earlier, the contribution of capital-intensity growth to productivity growth with the aggregate method is $\alpha(dk/k)$. In addition to the biases in aggregate α, there is also a (potentially offsetting) bias in dk/k. This bias occurs because the aggregate method does not distinguish between two different effects—changes in the aggregate capital-labor ratio, k, that are due to growth of capital intensity within sectors, and changes that are due to shifts in employment shares among sectors with different levels of capital intensity. These compositional shifts are important because of the persistent tendency for sectors with relatively low capital-labor ratios (except agriculture) to expand their shares of employment over time. Therefore, the rate of growth of the aggregate capital-labor ratio understates the combined within-sector rates of growth and the combined effects of their decelerations over the three subperiods.

The empirical importance of this effect can be seen from Table 10, which decomposes the aggregate growth of the capital-labor ratio into rate and level effects using equation (B-2) in Appendix B. The rate effect accounts for the within-sector growth of capital intensity, while the level effect measures the net contribution of shifts among sectors with different capital-labor ratios. The level effect is negative in all three periods, and declines in absolute value over time. Hence the growth rate of the aggregate capital-labor ratio (the total effect in Table 10) understates the amount of growth of within-sector capital intensity (the rate effect) during the three time periods, and also understates the extent of its decline.

Table 10
Breakdown of Aggregate Capital-Labor Growth Into Rate and Level Effects

	1948–65	1965–73	1973–78
Total	2.80	2.47	1.83
Change from Prior Period	—	−0.33	−0.64
Rate Effect	3.26	2.86	2.17
Change from Prior Period	—	−0.40	−0.69
Level plus Interaction Effect	−0.46	−0.39	−0.34

Source: Equation B-2 in Appendix B, using subperiod averages for share variables.

The biases in aggregate α and in dk/k are in part offsetting, but because of their combined effect, the aggregate method underestimates the importance of capital-intensity growth in the *slowdown* of aggregate labor-productivity growth. With the disaggregated method, slower capital-intensity growth accounts for 0.94 percentage point (almost one-half) of the 2.00-percentage-point decline in labor-productivity growth between the 1948-65 and 1973-78 periods, as opposed to 0.65 percentage point (one-third) of the decline with the aggregate method. A detailed analysis of the aggregation bias from a theoretical point of view is presented in Appendix B.

III. Summary and Conclusions

The growth rate of aggregate labor productivity slowed from 3.2 percent per year in the 1948-65 period, to 2.3 percent and 1.2 percent in the 1965-73 and 1973-78 periods, respectively. In this study we have analyzed the linkages among the sectors and the aggregate. The results indicate that the sharp productivity slowdown was widely dispersed across most sectors of the economy. Moreover, almost half of the slowdown was related to capital investment's failure to keep up with the rapid growth of the labor force.

Similar results were evident from our analysis of the broader measure, total factor productivity. This measure showed a deceleration from a 1.3-percent annual growth rate in the 1948-65 period to rates of 0.7 percent over 1965-73 and 0.4 percent over 1973-78. This deceleration also occurred widely across most sectors.

Intersectoral shifts in employment and output—the "level" effect—explained only a minor part of the aggregate productivity slowdown. The effect of shifts across sectors with differing productivity levels was relatively small in the early period (0.43 percent per year over 1948-65), and was even smaller in recent years (0.15 percent per year over 1973-78). The diminution of the level effect thus accounted for only 0.3 percentage point of the 2.0-percentage-point deceleration in aggregate labor-productivity growth.

The small level effect evident in the U.S. private economy over the past generation contrasts starkly with the large sectoral-shift effects normally evident in rapidly industrializing countries, where workers move rapidly from low-productivity agricultural employment to high-productivity industrial jobs. The productivity boost from sectoral shifts of this type, once important in U.S. economic history, apparently is no longer so.

Reduced growth of capital deepening explains almost half of the labor-productivity slowdown on a disaggregated basis, but only one-third of the slowdown on an aggregate basis. The aggregate method understates the importance of the slowdown in capital deepening, because of aggregation bias. Our theoretical and empirical results strongly support the use of disaggregated data—which is important because most other productivity studies have relied on aggregated data. Shifts in employment shares among sectors can cause difficulty, both in the estimation of the production function and in its application to questions such as those examined here. While it would be impossible to avoid these difficulties altogether, it is still worthwhile to disaggregate the data as far as possible.

The effect of the slowdown in capital-intensity growth on labor productivity growth was paralleled by a coincident decline in total factor productivity growth. The two trends signify not only a decelerating substitution of capital for labor, but also a deterioration in the rate of increase in the combined efficiency of the two inputs. That trend, in fact, has pervaded most sectors of the economy. The aggregate observations were confirmed—if not strengthened—by the disaggregated analysis.

The underlying causes and possible remedies of these worrisome trends have become the subject of much controversy. A number of contributing factors have been cited for the productivity slowdown, such as rapid increases in the number of inexperienced workers, business-cycle uncertainties, higher energy prices, inflation, governmental regulations, environmental priorities, and tax laws. Although all factors seem to have had some impact, no single one stands out as the prime cause of the slowdown in capital deepening or productivity growth. But our analysis suggests that, whatever the underlying causes, the effects of the slowdown have been pervasive throughout the economy.

Appendix A
The Rate Effect and Divisia Aggregation

One can interpret the rate effect under direct aggregation as a close counterpart to labor-productivity change as measured by Divisia aggregation. Economists believe Divisia aggregation to be particularly appropriate for measuring productivity change,[28] because this approach is consistent with generalized production functions such as the translog function, and because the aggregate index is based on a weighted average of within-sector rates of change, thereby effectively netting out level effects. For the multisector Divisia index of aggregate productivity, outputs and inputs are not summed directly across sectors as they are under direct aggregation. Instead, growth rates of real outputs (inputs) are calculated for each of the sectors, and the aggregate index of real output (input) growth is then computed as a *weighted average* of the growth rates of real outputs (inputs) in each of the sectors, where the weights are *nominal* output (nominal input) shares. The Divisia productivity index is thus the difference between the instantaneous rates of growth of output and inputs.

In algebraic form, the multisector Divisia productivity index may be stated[29]

$$\frac{dP}{P} = \Sigma y_i \frac{dQ_i}{Q_i} - \Sigma w_i \frac{dL_i}{L_i}, \qquad \text{(A-1)}$$

where y_i = nominal output share of the i-th sector

Q_i = real output of the i-th sector

w_i = nominal wage share of the i-th sector

L_i = labor hours employed in the i-th sector

The Divisia index is a continuous index, although it is normally approximated with a discrete counterpart because of the unavailability of continuous output and input data.[30] With annual data, the above formula can be approximated for annual growth rates:

$$1 + \frac{\Delta P}{P} \approx \frac{1 + \Sigma y_i \dfrac{\Delta Q_i}{Q_i}}{1 + \Sigma w_i \dfrac{\Delta L_i}{L_i}} \qquad \text{(A-2)}$$

where the annual subscripts have been suppressed for simplicity.

There are two conceptual differences between the direct and Divisia productivity indices. First, the Divisia index essentially measures only the rate effect, and hence is free of the "bias" imparted by a level effect. In the aggregate Divisia index, within-sector growth rates are weighted by shares that sum to one, so that the growth rate of the aggregate index reflects only the weighted average of the growth rates within the individual sectors. Second, the Divisia index weights the growth rates of sectoral components by their *nominal* output and factor shares. These nominal shares are the products of real shares and relative prices, the latter of which proxy for the marginal values (outputs) and marginal products (inputs). Thus, the Divisia index is effectively a value-weighted "rate" index.

The similarity between the Divisia index and the direct-aggregation-rate effect can be demonstrated easily. From equation (1) in the text, the continuous form of the rate effect in direct aggregation is

$$\Sigma q_i \frac{dP_i}{P_i},$$

which can be rewritten as

$$\sum q_i \frac{dQ_i}{Q_i} - \sum q_i \frac{dL_i}{L_i}. \qquad \text{(A-3)}$$

By comparison, the Divisia index in equation (A-1) can be rewritten as

$$\sum p_i q_i \frac{dQ_i}{Q_i} - \sum v_i\, l_i \frac{dL_i}{L_i}, \qquad \text{(A-4)}$$

where p_i = the relative price of output in the i-th sector

v_i = the relative wage of labor in the i-th sector.

Equations (A-3) and (A-4) demonstrate that the rate effect under direct aggregation and the Divisia productivity index are identical, except that the rate effect uses real output shares as weights (even for inputs), whereas the Divisia index uses nominal output and input shares as weights for outputs and inputs, respectively.

Table A-1 demonstrates that the rate effect and the Divisia index result in strikingly similar measures of aggregate-productivity change. Thus, both the rate effect and the Divisia index provide a good measure of productivity change net of "aggregation bias," and the choice between the two rests largely on whether or not one prefers to weight data by prices as proxies for marginal products.

Table (A-1)
Two Measures of Labor Productivity Growth
(Annual rate, in percent)

	1948–65	1965–73	1973–78
Rate Effect	2.82	2.05	1.14
Percentage Point Change	—	−0.77	−0.91
Divisia Index	2.80	2.07	1.18
Percentage Point Change	—	−0.73	−0.89

Sources: Table 3 in the text for the rate effect. Equation (A-2) is iterated annually for the Divisia index.

Appendix B
Aggregation Bias

Aggregation bias may occur when sectors with varying characteristics are treated as if they were homogeneous. If there were no aggregation bias—that is, if all components of the aggregate were alike—the two methods used in this paper to calculate the contribution of the capital-labor ratio to productivity growth would produce the same results. However, the empirical results indicate that this is not the case. To examine the theoretical difference between the two methods, we first need to separate changes in the capital-labor ratio into rate and level effects, deriving results analogous to equation (3) for labor-productivity change. Since

$$k = \Sigma l_i k_i \,, \qquad \text{(B-1)}$$

then

$$\frac{dk}{k} = \Sigma l_i \frac{dk_i}{k} + \Sigma \frac{k_i}{k} dl_i$$

$$= \Sigma \frac{\frac{L_i}{L}}{\frac{K}{L}} \frac{K_i}{L_i} \frac{dk_i}{k_i} + \Sigma \frac{k_i}{k} dl_i \qquad \text{(B-2)}$$

$$= \Sigma \frac{K_i}{K} \frac{dk_i}{k_i} + \Sigma \frac{k_i}{k} dl_i$$

From equation (4), the contribution of the capital-labor ratio to labor-productivity change as measured by the aggregate method is $\alpha \frac{dk}{k}$, or:

$$\alpha \left[\Sigma \frac{K_i}{K} \frac{dk_i}{k_i} + \Sigma \frac{k_i}{k} dl_i \right] \qquad \text{(B-3)}$$

The contribution as measured by the disaggregated method, as previously described in equation (8), is $\Sigma q_i \alpha_i \frac{dk_i}{k_i}$. Clearly, the two calculations would produce identical results if

$$\Sigma \frac{k_i}{k} dl_i = 0 \text{ and } \frac{\alpha K_i}{K} = \alpha_i q_i, \text{ or } \frac{\alpha}{\alpha_i} = \frac{Q_i/Q}{K_i/K}.$$

These conditions would be fulfilled if the sectors were homogeneous, since then $k_i = k$ for all i, and thus the term $\Sigma \frac{k_i}{k} dl_i$ is zero by definition. Also, since the output-capital ratios would be the same across sectors, $Q_i/K_i = Q/K$. The aggregate α could then be derived from equation (9), setting $\alpha_i = \alpha_j$ for all i and j.

$$\alpha = \alpha_i \Sigma \frac{Q_i/K_i}{Q/K} \frac{dK_i}{dK} = \alpha_i \Sigma \frac{dK_i}{dK} = \alpha_i \frac{1}{dK} \Sigma dK_i \quad \text{(B-4)}$$

and since $\Sigma dK_i = dK$, $\alpha = \alpha_i$.

In this situation, therefore, there is no ambiguity involved in the definition of the aggregate α, which is independent of the data. Since there is no aggregation bias, use of a disaggregated method provides no further information.

Given the Cobb-Douglas production function and a perfectly competitive economy, the two methods would also produce the same results so long as there were no employment shifts among sectors. The Cobb-Douglas function implies $\frac{\delta Q_i}{\delta K_i} = \alpha_i \frac{Q_i}{K_i}$ for all i, and perfect competition implies $\frac{\delta Q_i}{\delta K_i} = \frac{\delta Q_j}{\delta K_j}$. Therefore, $\alpha_i \frac{Q_i}{K_i} = \alpha_j \frac{Q_j}{K_j}$, and from equation (B-4),

$$\alpha = \Sigma \alpha_i \frac{Q_i}{K_i} \frac{K}{Q} \frac{dK_i}{dK} = \frac{\delta Q_i}{\delta K_i} \frac{K}{Q} \Sigma \frac{dK_i}{dK} = \frac{\delta Q_i}{\delta K_i} \frac{K}{Q} \quad \text{(B-5)}$$

Hence, the condition $\alpha \frac{Q}{K} = \alpha_i \frac{Q_i}{K_i}$ would hold under constant employment shares even if the sectors were not perfectly homogeneous. However, the existence of sectoral shifts in employment shares will result in a difference between the aggregate and disaggregated methods, so long as sectors are not homogeneous. Specifically, the difference will be $\alpha \Sigma \frac{k_i}{k} dl_i$, or the level effect in capital-labor ratio growth multiplied by α.

The existence of this level effect also introduces bias into the ordinary-least-squares estimation of the aggregate α. Since sectors with higher capital-labor ratios typically have higher labor-productivity levels, the shift effect, $\Sigma \frac{k_i}{k} dl_i$, in the growth equation for the capital-labor ratio (B-2) is correlated with the level effect in equation (7), which (from footnote 8) can be written equivalently as

$$\frac{dP}{P} = \underset{\text{(Rate)}}{\Sigma q_i \frac{dP_i}{P_i}} + \underset{\text{(Level)}}{\Sigma \frac{P_i}{P} dl_i}. \quad \text{(B-6)}$$

Hence the independent variable in the aggregate-productivity equation (4), dk/k, is correlated with the error term. This can be seen by first adding an error term to equation (4) for the aggregate and sectors, assuming for simplicity that $r = 0$ (no disembodied technical change):

$$\frac{dP}{P} = \alpha \frac{dk}{k} + u \quad \text{(B-7)}$$

and

$$\frac{dP_i}{P_i} = \alpha_i \frac{dk_i}{k_i} + u_i \quad \text{(B-8)}$$

Then, substituting (B-8) into (B-6), and (B-2) into (B-7), we have:

$$\frac{dP}{P} = \Sigma q_i \alpha_i \frac{dk_i}{k_i} + \Sigma q_i u_i + \Sigma \frac{P_i}{P} dl_i = \alpha \Sigma \frac{K_i}{K} \frac{dk_i}{k_i} + \alpha \Sigma \frac{k_i}{k} dl_i + u. \quad \text{(B-9)}$$

Rearranging terms, (B-9) becomes

$$u = \Sigma q_i u_i + \Sigma \left(q_i \alpha_i - \alpha \frac{K_i}{K} \right) \frac{dk_i}{k_i} + \Sigma \left(\frac{P_i}{P} - \alpha \frac{k_i}{k} \right) dl_i. \quad \text{(B-10)}$$

As before, if the sectors are homogeneous, $\alpha_i q_i = \alpha K_i/K$, $P_i = P$, and $k_i = k$. Then, the second two terms in (B-10) reduce to zero, and the error term, u, is composed only of the weighted random components u_i. If the sectors are not homogeneous, however, the error term will consist solely of random components only if there is no aggregation bias. As before, this condition will be met if the Cobb-Douglas and perfect-competition assumptions hold, so that $\alpha Q/K = \alpha_i Q_i/K_i$, and if there are no changes in employment shares. If the Cobb-Douglas and perfect-competition assumptions hold, but there are shifts in employment shares, (B-10) reduces to:

$$u = \Sigma q_i u_i + \Sigma\left(\frac{P_i}{P} - \alpha\frac{k_i}{k}\right)dl_i. \qquad \text{(B-11)}$$

Recalling that $P = Q/L$, $k = K/L$, and making use of the relation $\alpha_i q_i = \alpha K_i/K$, we can write equation (B-11) as

$$u = \Sigma q_i u_i + \Sigma q_i(1-\alpha_i)\frac{dl_i}{l_i}. \qquad \text{(B-12)}$$

The estimate of α will be biased if the nonrandom part of the error term, $\Sigma q_i(1-\alpha_i)\frac{dl_i}{l_i}$ is correlated with $\frac{dk}{k}$. The level or bias effect in $\frac{dk}{k}$, i.e., the second term in equation (B-2), is

$$\Sigma\frac{k_i}{k}\,dl_i, \text{ or } \Sigma\frac{K_i}{K}\frac{dl_i}{l_i}$$

Substituting $\frac{K_i}{K} = \frac{\alpha_i}{\alpha}q_i$, this term becomes $\frac{1}{\alpha}\Sigma\alpha_i q_i\frac{dl_i}{l_i}$. Since the nonrandom part of u is $\Sigma q_i\,(1-\alpha_i)\,\frac{dl_i}{l_i}$, the degree to which α is biased depends on how close $(1-\alpha_i)$ is to α_i. We know that the α_i must lie between 0 and 1; the closer they are to 0.5, the closer will be the correspondence between the independent variable and the error term in equation (4).

As we have seen, the industry output-capital elasticities in fact cover a fairly wide range, .2 to .7 (Table 9). However, the unweighted average is .50, while the average weighted by output shares is .45. Therefore, there is some indication that the independent variable, dk/k, in the aggregate equation (4) (or equation (6)) is positively correlated with the error term. This correlation should produce an upward bias in the estimation of α in the aggregate equation. This seems to be the case, because of the discrepancy between the estimates of α and α_i in Table 6.

RATE AND LEVEL EFFECTS

Several studies have decomposed aggregate productivity change into rate and level effects, but the formulae used were complicated and difficult to interpret. Nordhaus (1972) derived a multi-sector framework that somewhat resembled the one in this paper. Independently, Grossman and Fuchs derived a two-sector model that was simplified and extended by Beebe. Subsequently, Clark and Blakemore formulated and solved the multisector problem much more concisely, and their analysis was used by Haltmaier. The derivation below extends that of Clark and Blakemore, and results in a decomposition that is easily interpreted and applied.

Using the following definitions,

Q_i = real output in the i-th sector ($i=1, \ldots, N$)

Q = ΣQ_i = aggregate real output

q_i = Q_i/Q = i-th sector's share of real output

L_i = labor hours employed in the i-th sector

L = ΣL_i = aggregate hours employed

l_i = L_i/L = i-th sector's share of hours employed

P_i = Q_i/L_i = real output per hour in the i-th sector

P = Q/L = aggregate output per hour

and beginning with the identity,

$$P \equiv Q/L = \frac{\Sigma Q_i}{L} = \frac{\Sigma P_i L_i}{L} = \Sigma P_i l_i ,$$

then for a discrete time period,

$$\Delta P = \Sigma l_i \Delta P_i + \Sigma P_i \Delta l_i + \Sigma \Delta P_i \Delta l_i ,$$

where the three terms represent the rate, level, and interaction (second order) terms, respectively. For a percentage change over the finite interval,

$$\frac{\Delta P}{P} = \frac{1}{P}\Sigma l_i \Delta P_i + \frac{1}{P}\Sigma P_i \Delta l_i + \frac{1}{P}\Delta P_i \Delta l_i .$$

Using the following identities,

$$P \equiv Q/L;\ l_i \equiv L_i/L;\ P_i \equiv Q_i/L_i$$

and

$$\frac{P_i}{P} \equiv \frac{Q_i/L_i}{Q/L} , \text{ or } \frac{1}{P} = \frac{Q_i/Q}{L_i/L}\frac{1}{P_i} ,$$

and substituting into the above equation,

$$\frac{\Delta P}{P} = \Sigma\frac{L_i}{Q}\Delta P_i + \Sigma\frac{Q_i/L_i}{Q/L}\Delta l_i + \Sigma\frac{Q_i/Q}{L_i/L}\frac{1}{P_i}\Delta P_i \Delta l_i$$

$$= \Sigma\frac{L_i}{Q}\frac{P_i}{P_i}\Delta P_i + \Sigma\frac{Q_i}{Q}\frac{1}{l_i}\Delta l_i + \Sigma\frac{\Delta P_i}{P_i}\frac{Q_i}{Q}\frac{\Delta l_i}{l_i}$$

$$= \Sigma\frac{Q_i}{Q}\frac{\Delta P_i}{P_i} + \Sigma\frac{Q_i}{Q}\frac{\Delta l_i}{l_i} + \Sigma\frac{Q_i}{Q}\frac{\Delta P_i}{P_i}\frac{\Delta l_i}{l_i}$$

$$= \Sigma q_i\frac{\Delta P_i}{P_i} + \Sigma q_i\frac{\Delta l_i}{l_i} + \Sigma q_i\frac{\Delta P_i}{P_i}\frac{\Delta l_i}{l_i},$$

which are the rate, level, and interaction effects used in the text.

FOOTNOTES

1. Denison (1973) and Nordhaus (1972). Because these studies were done prior to the 1973 business-cycle peak and the economy had not recovered fully from the effects of the 1970 recession, it was difficult to measure the secular productivity slowdown.

2. Such shifts may be tied in part to the relative supplies of inexperienced and experienced workers. See Perry and Wachter and Perloff.

3. For example, see Thurow, pp. 86–87.

4. For other recent papers that employ various degrees of disaggregation, see Norsworthy, Harper, and Kunze, Haltmaier, Gollop and Jorgenson, Gollop, Kendrick and Grossman, and Bennett.

5. For an extensive analysis, see Norsworthy, Harper, and Kunze. For comprehensive summaries see Kendrick, Denison, and Tatom. Other recent papers of importance are by Berndt, Crandall, Nordhaus (1980), and Kopcke.

6. Direct aggregation is not the only method of aggregation; nor is it necessarily the best, particularly in the case of productivity. However, it is used officially and is commonly understood—all official published productivity data are based on direct aggregation. For these reasons, the formulae derived in this paper are based on direct aggregation, although we compare our results to those obtained using Divisia aggregation.

7. Equation (1) can be calculated over a full period or calculated iteratively within the period. For example, in analyzing the rate, level, and interaction effects over, say, a 10-year period, one could perform a single calculation for the entire period using the q_i at the beginning of the 10-year span and the full 10-year percentage changes in each of the other variables to arrive at the calculated components. The rate, level, and interaction components would sum to the total, with each component and the total expressed as a 10-year percentage change. In converting to annualized compound rates of change, however, the components no longer would sum to the total because of nonlinearities involved in compounding. (See Levine for a generalization of this problem.)

An alternative is to iterate equation (1) annually (or over any other short period), calculating a rate of change for the total and each component for each year in the 10-year period and allowing the q_i to change for each year. This method, which is used throughout the paper, has three advantages: the annualized growth rates of components always sum to that of the total; the q_i are representative of the average values of each subperiod rather than simply the initial values; and the method of calculation is comparable to that of the annual Divisia index against which the rate effect is compared in Appendix A.

8. An individual sector's contributions to the overall rate, level, and interaction effects are respectively,

$$q_i \frac{\Delta P_i}{P_i}, \quad q_i \frac{\Delta l_i}{l_i}, \text{ and } q_i \frac{\Delta P_i}{P_i} \frac{\Delta l_i}{l_i}$$

Since q_i/l_i may be expressed alternatively as P_i/P (the sector's relative level of productivity) the level effect may also be written as

$$\Sigma \frac{P_i}{P} \Delta l_i \quad \text{and} \quad \frac{P_i}{P} \Delta l_i$$

In this form, the level effect is the change in the sectors' labor shares weighted by their relative productivity levels.

9. The private domestic nonresidential economy excludes output of government and government enterprise, "rest of the world," and the imputed rental value of farm and nonfarm dwellings. Residential construction is included in the total.

10. Labor productivity exhibits a strong cyclical component, because the stock of capital is largely fixed in the short run and labor may be combined with capital at differing intensities. Moreover, because there may be significant costs associated with labor turnover, fluctuations in labor productivity tend to lag the business cycle (see Gordon and Sims). For the data in this section, the cycle in productivity is removed by calculating trends between selected "peak" years for productivity: 1948, 1965, 1973, and 1978. (see Norsworthy, Harper, and Kunze, pp. 389–90.) For the regressions in Section II, a cyclical variable is entered directly into the equations to account for the cyclical component of productivity. Moreover, the entire analysis was performed on cyclically adjusted output and labor data that were constructed using an econometric scheme derived from work by Clark (1978) and Nordhaus (1972). The results based on cyclically adjusted data were very close to the ones reported here. The two methods gave similar growth rates because the end points of the periods are peak productivity years.

11. The relatively steady behavior of the productivity series for finance and insurance and for services may result from unreliable output data. See Footnote 12.

12. The decline in the construction industry is sometimes attributed to erroneous real-output data, although it is difficult to explain why data problems would cause a sudden shift in the behavior of the series. In the construction, finance and insurance, and service industries, output is measured in terms of inputs in several constituent industries where there is no standardized product. There also is inadequate correction for quality change in the price indices within these industries. These problems suggest that the output and productivity data for these sectors may be of insufficient quality for productivity analysis, although they do not suggest that the shifts in trends are necessarily linked to data problems. See Norsworthy, Harper, and Kunze, p. 393, and Rees.

13. Pre-1972 data were utilized in some studies that attributed the deceleration in the late-1960's and early-1970's to the level effect. Because of the difficulty in removing the cyclical effect of the 1970 recession from the data, the years beyond 1968 could be relied on only tenuously. At that time, the diminished level effect due to the declining shift out of agriculture appeared to explain a large part of the small deceleration then apparent in aggregate productivity growth. The recent contention of Thurow, pp. 86–88, reiterating the present importance of the level effect, simply is not supportable using disaggregation at the level used in this (or his) study.

14. To get the rate effect, one does not simply multiply the real product share in Table 1 times the annual rate of increase in Table 2, although these figures are appropriate for analyzing that effect. For its calculation, see Footnote 7.

Sectoral level effects are not shown in Table 4 because the individual level effect is negative if Δl_i is negative, i.e., if the sector's labor share declined over the period. So long as a sector's labor share increased, the level effect is positive even if the sector displays relatively low productivity. Thus, the level effects measure only a portion of the full effect on aggregate productivity when labor shifts from one sector to another. To see this, consider what would happen if a worker were to shift from the agricultural to the manufacturing sector. Both output and employment would fall in agriculture, but would rise in manufacturing. The full effect of such a shift depends on the productivity levels in *both* sectors, and thus cannot be picked up by a level effect associated with a single sector. Generalizing from this example suggests that one should focus on the aggregate level effect (Table 3) rather than on the individual level effects of the sectors.

Separate analysis by the authors shows that the most important labor shifts impinging on the level effect have been the declining share of labor in agriculture (a sector with a low *relative level* of productivity); an increasing labor share in services (low relative productivity level) and finance and insurance (high relative productivity level); and a shift in mining (high relative productivity level) from a declining to a rising labor share. Although the labor shares of the manufacturing sectors have declined on balance, the productivity levels of these sectors are very close to the aggregate average.

15. As noted in Table 5, capital data are for gross capital stocks. The sources are the Department of Commerce for agriculture and manufacturing, and Data Resources, Inc., for the other sectors. (Data for the total are sums of the sectoral data.) The analysis was performed also using sectoral data by Kendrick and Grossman. The results were comparable except for a few sectors, most notably mining, where the estimated α's made little sense. Jane Haltmaier is exploring other data sources, but we are not yet prepared to make strong statements about the quality of our data. We have also run our equations using Commerce data for aggregate gross and net capital stocks, and we report these results in the paper.

16. Norsworthy, Harper and Kunze found that the capital-labor ratio accelerated in the 1965–73 period for the private nonfarm business sector. According to their analysis (pp. 419–20), the investment tax credit appears to have reduced the rise in the cost of capital during the 1965–73 period, while the sudden rise in energy prices in 1973–74 (and the apparent complementarity of energy and capital in production) may have retarded capital formation in the 1973–78 period.

17. Much debate has centered around the inclusion of energy input or its price in a value-added production function. Most energy use should be excluded, although the price of energy might provide a reasonable surrogate for other factors, such as changes in the optimal capital-labor ratio. See Kopcke.

18. Strict separability requires that exclusion of some inputs, such as goods in intermediate stages of production, not affect the optimal mix of the included inputs, labor and capital.

19. Disembodied technical change and changes in total factor productivity are used interchangably to mean a shift in the production function. See Jorgenson and Griliches, p. 250, and Norsworthy, Harper, and Kunze, p. 395.

20. Under the assumptions that production conforms to the Cobb-Douglas formulation and that the economy is perfectly competitive, the elasticity of output with respect to each factor will be equal to that factor's share of total income. Thus, α can be estimated as capital's historical income share. This is the approach used by Denison.

21. Because capacity utilization in manufacturing is probably not a good surrogate for business conditions in many sectors, we experimented with other ways of removing the cycle in labor productivity. Data for normal hours and output were constructed using a technique based on work by Clark (1978) and by Nordhaus (1972). Although this method produced similar results, it is much more complex and has led to much controversy. We also used the method described in the paper, with percentage changes in 1972-dollar GNP (less the mean percentage change) in place of the capacity-utilization rate. Although real GNP is preferable because of its broader-based coverage, it imparts a bias because its percentage changes are endogenous to the *secular* trend in productivity. Therefore, we found it preferable to use the manufacturing capacity-utilization rate as a proxy for the economy-wide business cycle.

22. The dummies are zero except for the following years: $d_1 = 1$ for the annual changes 1965–66 through 1972–73, and $d_2 = 1$ for 1973–74 through 1977–78.

23. The means of the dependent variables are the average rates of labor-productivity change over the 1948–78 period, which can be approximated from Table 7.

24. Since only two factors of production (labor and capital) have been included in the estimated equations, it is difficult to say which figure should be used. The figures correspond to the shares of income (output) classified as (1) profit-type return only, and (2) profit-type return plus net interest, indirect business taxes, and capital consumption allowances. The latter share has been quite stable over the 30-year period, ranging from .39 to .47. The income (output) measure is gross domestic product, less government. Data are from Table 6.1 of the National Income and Product Accounts.

25. Net capital stock is not available on a disaggregated basis. In estimating our aggregate equation using the BEA series for net capital stock, we obtained an estimate of .55. Thus our empirical results are quite close to those of Clark.

26. Equation (9) is derived as follows:

$$\alpha = \frac{dQ}{dK}\frac{K}{Q} = \Sigma\frac{dQ_i}{dK_i}\frac{dK_i}{dK}\frac{K}{Q} = \Sigma\frac{dQ_i}{dK_i}\frac{K_i}{Q_i}\frac{dK_i}{dK}q_i\frac{K}{K_i}$$

$$= \Sigma\alpha_i q_i\left(\frac{dK_i}{K_i}\Big/\frac{dK}{K}\right)$$

27. Since the aggregate α depends on the sectoral mix of capital-stock growth, the concept of an aggregate α as a simple elasticity becomes ambiguous once one pursues the microeconomic approach. This problem, which is not new in economics, lies at the heart of the aggregate vs. sectoral relationships addressed in this paper.

28. Siegel, Jorgenson and Griliches, Solow, Norsworthy, Harper and Kunze, Gollop and Jorgenson, Gollop, Star and Hall, and Richter. The Jorgenson and Griliches paper, pp. 250–254 and 260–261, gives perhaps the clearest and most precise derivation of the multisector Divisia productivity index.

29. Jorgenson and Griliches, p. 252. There is also an equivalent dual counterpart expressed in terms of prices, since Divisia aggregation presumes that prices equal marginal values.

30. See Jorgenson and Griliches, p. 260–261, and Star and Hall.

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Conference Proceedings Available

Copies are now available of the **Proceedings** of the 1979 West Coast Academic/Federal Reserve Research Seminar. The **Proceedings** contain five papers (with discussion) on the effects of money on employment, output, prices and interest rates. The **Proceedings** are aimed primarily at an audience of financial analysts and academic economists. . . Free copies of the **Proceedings** of the 1979 conference—as well as the **Proceedings** of earlier (1978 and 1976) conferences—can be obtained by calling or writing the Public Information Section, Federal Reserve Bank of San Francisco, P.O. Box 7702, San Francisco 94120. Phone (415) 544-2184.

Inflation Expectations and the Housing Market

Randall J. Pozdena*

There is a growing consensus that inflation is not an entirely "neutral" process. Institutional features of the economy, such as tax and credit-market policies, can interact with inflation to affect relative prices, leading to disturbances in the levels of real activity in various sectors of the economy.[1] Nowhere is this phenomenon more evident than in the housing market. Significant changes in the relative price of housing have accompanied the general inflation of the last decade and a half. These events have also prompted changes in the level of housing consumption and patterns of housing tenure.

This article presents a simple model of the housing market and examines the behavior of the market during a period of rising inflation expectations. The demand for housing is viewed as the demand for an asset stock in a household or landlord's portfolio. This approach distinguishes between the "price" and user "cost" of housing, and emphasizes the role of expectations in determining housing demand. We describe how inflation expectations and other economic variables can produce observed changes in housing prices, rents, and tenure patterns.

The results of the analysis have a number of implications for housing policy and for the regulation of home-mortgage credit. In particular, we find little evidence that, in the aggregate, a "crisis" exists in the price or supply of housing, or that "affordability" has been a serious constraint. Moreover, we argue that the often-lamented decline in the rental market—with the related rise in conversions of apartments to condominiums—can be seen simply as a symptom of the market's adjustment to inflation pressures. Finally, the discussion puts into focus the current debate about the appropriate methodology for incorporating housing costs in the most commonly used index of prices, the Consumer Price Index (CPI).

The first section of this paper describes the trends in the housing market that have developed during the recent inflation. The second section presents a highly simplified view of the housing market, and explores the processes that determine housing prices, rents, and the balance between rental and owner-occupant modes of housing tenure. A third section provides some elaborations of the simple model, including its consistency with rational expectations and the effects of imperfections in the credit market. The fourth section presents empirical support for the thesis developed in this paper, and the final section discusses the policy implications of the paper's conclusions.

I. Recent Trends in Housing

The housing market has changed dramatically during the last decade, as seen most notably in the rapid increase in housing prices relative to most other prices in the economy. Between 1970 and 1980, the price of a single-family home[2] of a given quality increased at about a 9.3-percent annual rate, compared with a 6.8-percent annual rise in overall consumer prices (measured by the personal-consumption expenditures deflator). This increase in real housing prices (Chart 1), coupled with

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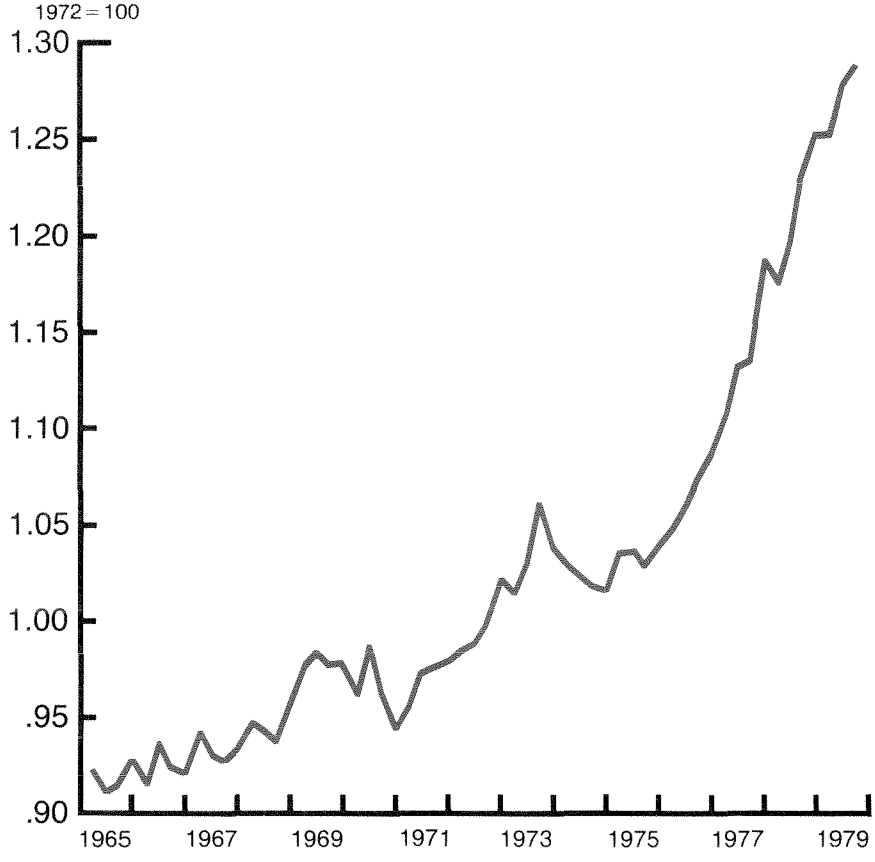
rising mortgage rates, has prompted officials to argue that housing had become "unaffordable." Yet, the consumption of housing services, by any measure, has apparently continued to rise. The simple number of housing units has grown faster than the population (Chart 2), while the quality of housing services has risen as well. The average new home in 1979 had a greater floor area, more bathrooms and bedrooms, and more amenities (such as garage space and central air conditioning) than a new home in 1970.[3]

Another major recent phenomenon has been the decline of the rental housing market. The earlier steep decline in the rental share of the housing market had slowed in the 1960s, but then accelerated again in the last decade. In 1970, 37 percent of all American families depended upon rental housing for their housing needs, but by 1980 the figure may have dropped to as low as 33 percent. Such a decline in the rental share would be four times greater than the percentage decline registered in the previous decade.[4]

As one of the manifestations of this trend, many young households, traditionally renters, have become owner-occupants. In 1970, only about 39 percent of household heads under the age of 30 were owner-occupants; by 1975 that proportion had increased to over 46 percent.[5] Although homeownership has broadened to include some relatively low-income young families, the very poorest families remain in rental housing. Renters on average earned 64 percent of the national median income in 1970, but only 55 percent in 1977.

Chart 1

Index of Real Housing Prices



In contrast to the trends in housing prices, housing *rents* have generally fallen relative to general consumer prices. Between 1970 and 1980, real rents declined approximately 10 percent (Chart 3). Combined, the trends in prices and rents have reduced the attractiveness of rental-property investment for many investors, despite the prospect of capital gains. The often-heard lament is that investment in rental housing does not "pencil out."[6]

In terms of the housing stock itself, the shift away from rental housing has taken two forms. First, the rate of construction of rental property has dropped significantly despite large Federal subsidies. In 1979, a generally average year for housing, total rental-unit construction (subsidized and unsubsidized) declined almost 20 percent from a year earlier. The 210,000 unsubsidized units started in 1979 was the lowest number in 20 years, and less than half the historic peak, and the number started in 1980 may have dropped as low as 120,000 units.[7]

Second, many existing multi-unit properties have been converted to condominiums. In 1979, 195,000 rental units were converted—up 70 percent in a single year. A more subtle form of conversion, however, has also occurred with a decline in the proportion of rented single-family homes. In 1970, 19.3 percent of single-family homes were occupied by renters; by 1976, this figure had fallen to 16.6 percent.[8]

Some policymakers see these trends as creating a dual "crisis" in housing. On the one hand, they fear that rising housing prices and mortgage rates are rapidly making owner-occupied housing "unaffordable."[9] On the other hand, they fear that the shrinking rate of new rental housing construction and the conversion of existing rental properties to condominiums are choking off the rental alternative. Policymakers have developed many responses to this perceived crisis, including expansion of governmental responsibility in the housing area. Indeed, in 1979, an estimated 75 percent of multifamily starts were Federally subsidized or insured, and governmental mortgage-assistance programs have proliferated, particularly at the local level. It is important, therefore, to understand clearly the genesis of the trends which have stimulated this policy response.

Chart 2

Occupied Housing Units Per Capita

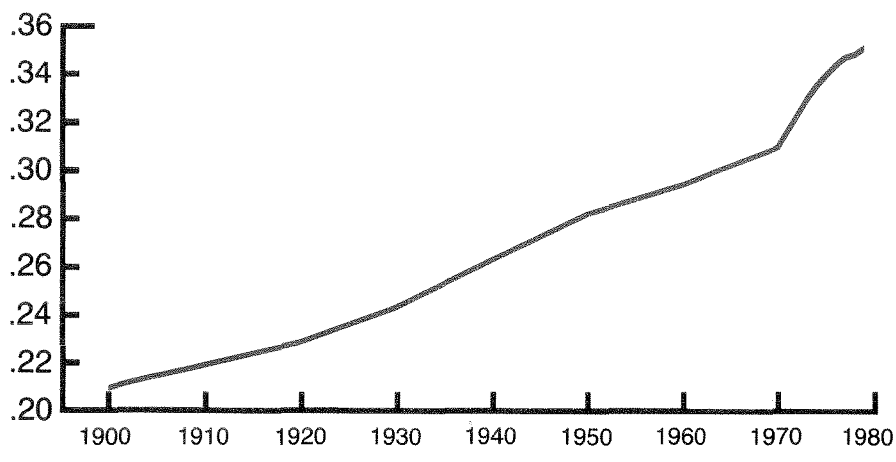
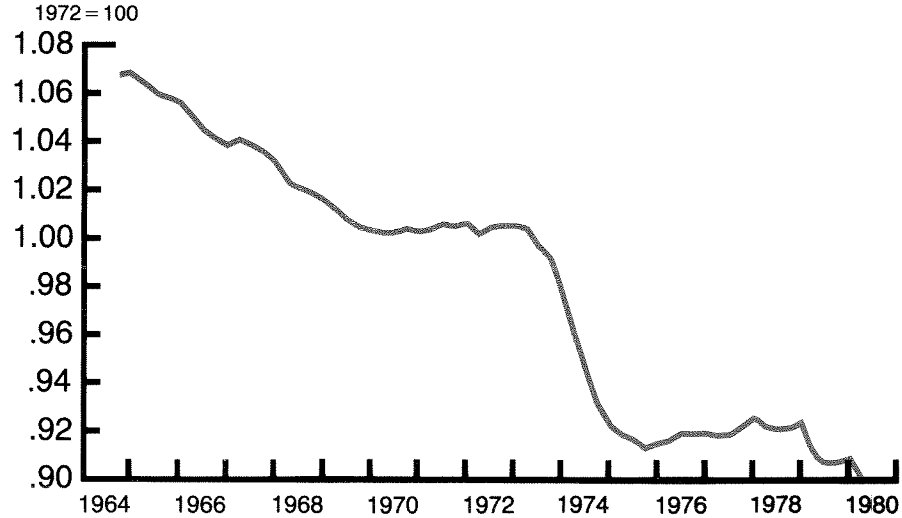


Chart 3
Index of Real Rental Costs



II. Modelling the Housing Market

In this section we employ a demand-and-supply model of the housing market to demonstrate how the economic environment of recent years has produced the changes noted above in housing prices, rents, and tenure patterns. The model first analyzes owner-occupied housing and then expands to incorporate the rental market as well. The discussion focuses on the market for the housing *stock,* but it also has implications for the market for housing *services,* because housing services flow in rough proportion to the stock.

To simplify matters, we assume that the housing stock can be meaningfully measured in quality-adjusted units. Thus an increase in the stock can be interpreted as either an increase in the number of structures, an increase in their quality (that is, their ability to produce housing services), or both.

Housing demand

The first step in devising our model is the specification of the demand for the housing stock. Many housing studies have treated the demand for the housing stock analogously to the demand for consumption goods, where the purchase price and the consumer's income are the relevant arguments of demand.[10] However, the housing stock is not a consumption good *per se,* but rather an asset that can be employed by owner-occupants to *produce* for themselves a flow of consumption services (shelter, privacy, access to community services, etc.) many periods into the future.

Viewed from this perspective, a consumer's decision on housing-stock ownership thus has features of both a consumption decision and an investment/production decision. This has several implications for the proper specification of the demand relationship. First, since a household uses housing over a period of time, the "price" variable relevant to today's housing demand is the expected *cost* of this use, relative to other prices, for each period over the planning horizon—not simply the purchase price of the asset itself. Obvious cost flows associated with homeownership include the foregone interest earnings on the equity in the house, the interest cost of borrowed funds, depreciation, maintenance, insurance, property taxes and real-estate transaction costs. In addition, however, the "investment" aspects of homeownership offer the prospect of capital gains or losses over the holding period; thus user costs are reduced by any expected increase in the value of the house.

Second, a household's consumption of goods and services—including housing services—apparently changes proportionally with the household's wealth or permanent income. Since housing services flow in proportion to the stock, stock demand thus should depend upon the household's real wealth—primarily, of course, the present value of expected future real income—as perceived by the household at the time it does its planning.

We can thus write the demand for housing assets more precisely as

$$D_o^* = f(U_n/P_c, W)$$

where U_n is the nominal user cost of housing capital (assumed for simplicity to be the same for each period in the planning horizon), P_c is the price of consumption goods each period, and W is a measure of real wealth.[11] The desired stock, D_o^*, is positively related to the scale variable, W, and negatively related to relative "prices," U_n/P_c, as in traditional consumer theory.

On the assumption that there are no income taxes and that depreciation, maintenance and property taxes can be ignored, the nominal user cost can be approximated by

$$U_n = iP_n - \dot{P}_e.$$

where i is the nominal interest rate on long-term investments, P_n is the nominal price of housing, and $\dot{P}_e$ is the expected nominal increase in home values. The first term in this equation is the interest cost of housing (that is, the sum of foregone interest on equity and borrowing cost) and the second term is the expected capital gain.

Income-tax law potentially affects this simple measure of an owner-occupant's user capital cost in a number of ways. First, interest income is taxable and interest payments are deductible from taxable income. Thus the interest rate should be expressed in after-tax terms. Second, U.S. tax laws potentially affect the capital-gains term in the user-cost formula. However, the exemptions from capital gains taxes are so liberal that, for practical purposes, the homeowner can anticipate receiving the gross capital gain.

Another important implication is the influence of inflation expectations on the nominal interest rate. In particular, if lenders expect prices to rise over an extended period into the future, they will require higher long-term interest charges in order to compensate for the expected loss in purchasing power. Empirical studies indicate that the relationship is a simple one: the nominal interest rate is the sum of the real interest rate and the expected rate of inflation.

Taking these tax features into account, and incorporating the assumption that the nominal interest rate is the sum of the real interest rate, r, and the expected rate of general price inflation, z, we may restate the nominal user cost as

$$U_n = P_n((r+z)(1-t) - (\dot{P}_e/P_n))$$
$$= P_n((r+z)(1-t) - h)$$

where h is the expected rate of inflation in housing prices and t is the household's marginal tax rate. Finally, dividing by P_c, the price of consumption goods, we obtain

$$U = P((r+z)(1-t) - h)$$

where $U = U_n/P_c$ is the real user cost relevant to the housing-demand relationship and $P = P_n/P_c$ is the real price of housing.

The conceptualization of housing demand as the demand for a durable good offers a number of insights which are often overlooked in analyses of the housing market. First, the factor which acts like a "price" variable in the demand relationship is not simply the current price of housing, but the *expected* cost to the owner of the housing asset per period. Unlike the typical consumption-good price, therefore, the analogous housing variable is inherently more difficult to observe because of its prospective nature.

Second, inflation expectations and taxes play an important role in determining user costs and, hence, housing demand. For example, if households expect housing prices to increase at the same rate as other prices in general (that is, z = h), then an increase in those expectations should cause real user costs to *fall* and, hence, housing demand to *rise*. The potency of the effect, however, is dependent upon the tax rate. If the tax rate is zero, real user costs will be insensitive to inflation expectations. (Of course, if housing inflation expectations differ from general inflation expectations, user costs would be sensitive to expectations regardless of the tax rate—as will be discussed later in the paper.)

The demand relationship can be illustrated graphically. The demand curve, D, for the stock of housing is downward sloping with respect to the real price (Figure 1), because lower housing prices imply lower user costs, everything else being equal. Changes in inflation expectations, the tax rate, the real interest rate or wealth will cause *shifts* in this curve. An increase in inflation expectations, for example, will shift the demand curve outward to D1.

Housing supply and market equilibrium

The equilibrium real price of housing assets is the price that equates the desired stock demand with the actual stock supply. In the short run, the latter is fixed, but in the long run, additions to the stock can be made as long as the real price that clears the market in the short run is above the price implied by long-run supply conditions. The long-run supply curve may not be perfectly elastic with respect to price, however, because one of the factors used in housing production—land—is in fixed supply.

Figure 1

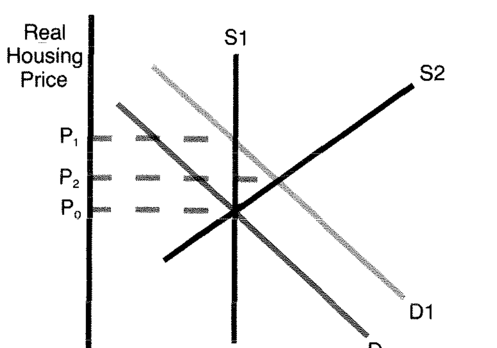


Figure 1 can be used to illustrate the response of housing prices and the housing stock to increased inflation expectations. The curve S1 represents perfectly inelastic supply, and the curve S2 represents more elastic supply conditions, as might prevail in the long run. The market is initially in long-run equilibrium at P_0. An increase in inflation expectations would cause the demand curve to shift from D to D1. In the short run, the real price would rise to P_1, inducing additional supply, until the long-run equilibrium price, P_2, is reached.

This simple model shows that first, the market is always in equilibrium, in the sense that housing-asset prices adjust to equate the desired and actual supply. Unless the long-run supply of housing is perfectly elastic, an increase in inflation expectations will thus cause a long-run increase in real housing prices. Second, this increase in real housing prices is a one-shot affair. For real housing prices to rise continuously relative to general prices, inflation expectations must continually be revised upward.

Third, the model helps distinguish between movements in the price of housing and movements in the user cost of housing. The rise in the real *price* of housing that accompanies an increase in inflation expectations does not necessarily imply that the real user *cost* has risen. On the contrary, in the case of fixed supply and unchanged wealth, an increase in inflation expectations leaves the real user cost unchanged. Otherwise the desired stock (which depends upon the user cost) would differ from the fixed supply. The real price has simply risen to offset the initial reduction in U caused by the increase in inflation expectations, and makes households willing once again to hold the available stock of housing.

Similarly, the real user cost of housing must *fall* in response to an increase in inflation expectations when supply is elastic. Otherwise, households would be unwilling to hold the increased stock supply that is stimulated by the rise in the real price of housing.

Other variables can also affect the relative movement of housing prices and costs. Consider, for example, the effect of a change in wealth. Unless supply is perfectly elastic, an increase in demand caused by an increase in wealth will cause real prices to rise. Since there is no change in inflation expectations to offset this effect, the user cost must also rise. This is necessary to clear the market for the available stock at the higher level of real wealth.

Finally, consider the effect of an increase in the interest rate (nominal or real). This causes the demand for the housing stock to decrease, everything else being equal. If the housing supply is imperfectly elastic, this will, in turn, cause real housing prices to *fall* and the housing stock to decline. (In Figure 1, demand shifts back from D1 to D and the price falls from P_2 to P_O.) With unchanged wealth, however, the decline in the housing stock can be made consistent with demand only if real user costs are higher in equilibrium.

These examples make it clear that housing prices do not always move in the same direction as the perceived *cost* of housing to the consumer. Indeed, in the examples above, only changes in wealth affected user costs and prices in the same way. Since it is housing *costs* that are relevant to housing demand—and the consumer's welfare—the use of housing prices in the consumer-price index is thus theoretically unsatisfactory and may lead to biased measures of inflation. Indeed, under circumstances of rising inflation expectations, the use of housing *price* data creates the impression that *costs* are rising when precisely the opposite may be true. We will return to this issue later in this paper.

III. The Rental Market

The model of the housing market described above involved owner-occupants only. This approach permitted a simplified presentation while still offering useful insights into the workings of the housing market. Moreover, since owner-occupancy is the dominant mode of housing tenure in the United States, such a simplification is useful in the aggregate. However, this begs an interesting question: why *is* homeownership so dominant?

Frequently it is said that Americans prefer certain features of owner-occupied housing, which differs qualitatively from rental housing. This view suggests that rents and owner-occupant user costs can move with considerable independence; indeed the relative level of these variables would determine the tenure balance. This "segmented markets" approach has been followed in several recent studies of the home-ownership decision.[12] Such an approach, however, seems somewhat *ad hoc*. It is difficult to conceive of important housing *services* that can not be obtained in the rental market; essentially all types of housing are available on a rental basis. There are other distinctions, of course, that arise as a result of the nature of the transactions involved—homeownership may impede mobility, for example—but such transaction costs tend to affect the level of owner-occupant housing costs, and not necessarily their relationship to the market rent for similar housing.

We take an alternative approach, assuming that there is no important distinction between the services of rental and owner-occupied housing, and argue that other factors determine the equilibrium tenure share. In particular, we extend the model to incorporate the different tax treatment of landlords and owner-occupants. We illustrate how taxes alone can make the tenure balance determinate even when market rents, and owner-occupant user costs, are equal on the margin.

Tax policy and the rental market

Both landlords and owner-occupants perceive a user cost of capital associated with ownership of housing. Indeed, if a rented unit were indistinguishable from an owner-occupied unit—and if there were no difference in tax treatment—the user cost perceived by the landlord would be the same as that perceived by an owner-occupant. A landlord would be unable to charge a rent in excess of this user cost because households, by assumption, can obtain equivalent services through ownership. In such a case, the tenure balance would be indeterminate without additional assumptions about quality differences, tastes, transactions costs, or other factors.

In fact, of course, the tax system alters this simple description in several ways. First, tax law treats property owned by landlords and property owned by occupants quite differently. Unlike owner-occupants, landlords are taxed on the income that flows from their housing stock because that income is "realized" in the form of rental income. Landlords are also more likely to pay taxes on the nominal capital gains they enjoy. Both factors tend to make the breakeven rent that a landlord must charge greater than the user cost perceived by an owner-occupant facing a similar tax rate and level of inflation expectations. For example, assume that the landlord also faces the rate, c, on capital gains. Then the breakeven situation for the landlord is to charge a rent, R, per period, which, after tax, is equal to after-tax user costs. That is

$$R(1-t) = P((r+z)(1+t)-(1-c)z)$$

or

$$R = \frac{1}{(1-t)} P((r+z)(1-t)-(1-c)z).$$

This market rent is clearly greater than the implicit rent or user cost

$$U = P((r+z)(1-t)-z)$$

perceived by a similarly situated owner-occupant. Moreover, it can be shown that rents and owner-occupant user costs respond differently to changes in inflation expectations. In general, for capital-gains tax rates of a reasonable size, an increase in inflation expectations reduces R by less than it reduces U, everything else being equal.[13] This differential sensitivity to inflation expectations, as we shall see, may contribute importantly to changes in tenure patterns.

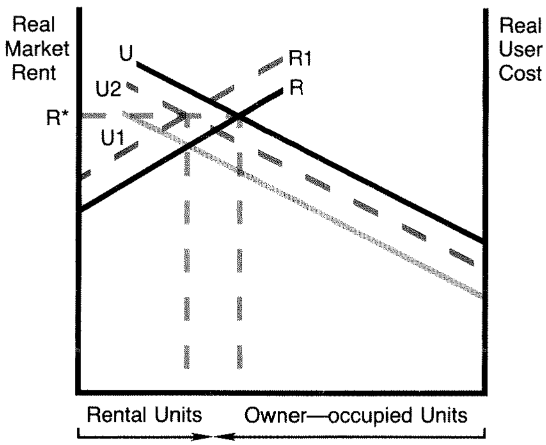
A second important aspect of income-tax policy is the differential impact of different tax rates. Because of the treatment of nominal interest, individuals in higher income-tax brackets perceive lower user costs of housing capital than do individuals in lower income-tax brackets. This applies to both landlords and owner-occupants. Market rents have to be quite high to encourage individuals in low income-tax brackets to own housing, either as landlords or occupants. This makes both the number of rental housing units and the number of owner-occupied units increasing functions of the market rent.

Rental-market equilibrium

These implications of the tax treatment of housing suggest a way to determine the equilibrium rent and tenure balance. First, given the assumption of qualitative equivalence of rented and owned housing, the market rent must equal the user cost of owner-occupancy on the margin. Otherwise some tenants would be motivated to become owner-occupants, or vice versa. Second, the total demand for housing at that rent (or user cost) must be exactly equal to the supply. Otherwise the price of housing would change (thereby affecting rents and user costs) to equilibrate demand and supply. Finally, given the assumption that there are no market imperfections to cause vacant or unused housing, the entire stock must be "supplied" by either landlords or owner-occupants.

The consequences of these conditions, given a fixed supply of housing, can be illustrated graphically (Figure 2). The curve labelled R represents the relationship between the market rent and the ownership or "supply" of rental units. The curve labelled U graphs the same relationship for owner-occupied housing. Both are increasing functions of the market rent (for the reasons given earlier), but are drawn back-to-back to incorporate the assumption of a

Figure 2



fixed total stock of housing. Both curves are drawn for a given price of housing and a given level of inflation expectations.

At the intersection of the supply curves U and R, two of the necessary equilibrium conditions are satisfied: the owner-occupant user cost equals the market rent, R*, and the total stock of housing is allocated between landlords and owner-occupants. As drawn (with a higher landlord-cost relationship) the tenure balance is skewed toward owner-occupancy. If R* also happens to be that rent which makes desired total demand equal to the fixed supply, then the figure fully describes the market equilibrium.

The diagram can be used to study the effect of changes in inflation expectations on rentals and tenure choice, since any factor which affects the user costs of landlords or owner-occupants can be graphed as shifts in the curves R and U, respectively. For example, if increased inflation expectations significantly reduce the user costs of owner-occupants (but not of landlords), then the curve U will shift downward to U1. The intersection of U1 with R describes a lower market rent (and owner-occupant user cost) as well as a further skewing of the tenure choice toward owner-occupancy.

This is not the final equilibrium, however, because the lower cost for both types of tenure will cause aggregate housing demand to exceed the fixed supply. Of course the variable which will move to ration the housing supply is the price of housing. Since supply is fixed, only one rental, R*, clears the market, and housing prices must rise enough to return user costs to this previous level. The increase in prices affects both landlords and owner-occupants, so the R curve shifts to R1 and the U curve shifts to U2 until the opportunity costs are the same as they were before the change in expectations.

Although opportunity costs are unchanged, owner-occupancy has been increased, or to put it somewhat differently, some rental housing has been converted to owner-occupied housing.[14] If aggregate supply were somewhat elastic (rather than fixed), real housing prices again would rise and the tenure balance would change in the direction of owner-occupancy, but real user costs and real rents would remain depressed relative to their initial levels.[15]

Relevance of model

The model presented above suggests that rising inflation expectations have significantly affected recent changes in housing prices, rents, and tenure patterns. Widely observed increases in real housing prices and in the equilibrium quantity of housing can be explained in this fashion. Of course, increases in demand caused by growing numbers of households or expanded wealth might also be responsible for these trends, given a somewhat inelastic supply. However, as the model suggests, such factors would cause real user costs (and, hence, real rents) to rise as well, and no such phenomenon has been observed. On the contrary, real rents have fallen quite consistently for over a decade. *In toto,* the relative behavior of housing prices and rents can best be explained by rising inflation expectations.[16]

Recent increases in owner-occupancy may also have been stimulated in part by the consequences of increased inflation expectations. Analysis of tax law suggests that such expectations may be more beneficial to owner-occupants than to landlords. As a consequence, rising inflation expectations will cause the tenure balance to shift toward increased owner-occupancy to restore the equivalence, on the margin, of the user costs faced by the two types of owners. It should be noted that this tenure shift occurs without movement in the relative *equilibrium* values of rents and user costs. Indeed, market rents are a useful measure of user costs.

By implication, the decline in the share of the housing market owned by landlords is accompanied by a change in the type of taxpayers who find housing ownership attractive on the margin. At reduced real rents, only very high-tax rate individuals remain as landlords, whereas owner-occupancy can be broadened only if relatively low-tax rate households are embraced. Both tendencies are consistent with our analysis concerning the proliferation of homeownership and the poor environment for investment in rental housing.

The analysis also helps explain the condominium-conversion phenomenon. In effect, the model suggests that rental property is converted because rising inflation expectations make the cost of holding a unit of housing in a household's portfolio lower for that household than for a landlord.[17] Tax policy makes the housing more valuable to potential owner-occupants than to the landlord, and conversion brings about the necessary redistribution. In reality, of course, actual conversion decisions depend upon changes in taste, landlords' fears of rent controls, and other factors. However, the model offers an economic rationale for this phenomenon that does not depend upon such ambiguous variables.

IV. Other Considerations

A highly simplified asset-stock demand model thus appears to be useful in analyzing present-day housing trends, at least in a casually empirical manner. A number of other considerations deserve discussion, however, because of their policy or empirical implications.

Credit-market imperfections

One such consideration concerns the effect of certain lending conventions on the behavior of the housing market. Lenders regularly employ loan-qualification standards which limit loan-income ratios, such as the ratio of monthly loan payments and the borrower's current monthly income. Critics argue that this practice, combined with the convention of a fixed payment mortgage, causes "affordability" problems as rising inflation expectations (and, hence, rising nominal interest rates) cause monthly loan payments to rise relative to income. (An unstated corollary of this view is that the rise in housing demand and prices can then only be explained by increases in wealth or by population-based demand pressures.)[18]

There is good reason to believe, however, that the "affordability" problem thus may have been only a minor element in recent housing-market trends. First, the qualification constraint may not be effectively binding in the long run because of changes in lender behavior. An increase in inflation expectations does not affect the ultimate "security" of a loan. Neither the present value of a fixed-payment loan, nor the present value of a borrower's income, differ at different *levels* of inflation expectations. Thus profit-oriented lenders have an incentive, as inflation expectations rise, to relieve the borrower of the constraint imposed by the qualification standard. This relief may take the form of a broadened income definition (which recognizes the spouse's income, for example), more liberal interpretation of qualification standards, or pressure on regulators to develop mortgage instruments (such as the graduated payment mortgage) which help borrowers overcome the cash-flow burden imposed early in the life of the typical fixed-payment mortgage.

Second, individuals have some ability to rearrange their asset portfolios so as to mitigate an undesired constraint on the amount of mortgage liabilities they hold in their portfolios. In particular, individuals may dissave to make larger contributions to home equity, and thereby reduce their mortgage requirements.

Finally, and most importantly, the notion of an increasingly binding "affordability" constraint is inconsistent with observed housing-market trends. A borrowing constraint, in effect, tends to raise the user cost of housing capital and, therefore, tends to raise real rents in equilibrium.[19] But if this constraint had tightened in recent years, real rents should have *risen* rather than fallen as they apparently have done. Of course, the possibility remains that loan-qualification practices and "cash flow" constraints have had some effect, but have been overwhelmed by other factors.

Speculation and the housing market

Our model suggests that inflation processes can produce changes in real housing prices during the transition period while the housing market adjusts to a new level of inflation expectations. With unchanged expectations about the general rate of inflation—and with housing-price expectations linked to these general expectations—prices would rise only at the rate of prices in general. Why, then, have we seen a relatively sustained rise in real housing prices over the last decade or so? One possibility that is consistent with the model is a frequent upward revision in overall inflation expectations—understandably so, since households were buffeted by an acceleration of *actual* inflation during this period.

Another possibility—one that is compatible with the popular notion of a "speculative bubble"—is the potentially self-reinforcing nature of the movements in housing demand and housing prices. This view, argues, in effect, that households have formed their housing inflation expectations separately from "general" inflation expectations (as incorporated in nominal interest rates), and that they have relied heavily on past housing-price movements to form these expectations. With such an adaptive model, it is easy to construct a scenario with an explosive rise in real housing prices, in the following manner. A real increase in housing price (however initiated) would cause individuals to expect additional increases. (In the language of our model, h increases more than z.) This, in turn, causes housing demand to rise and stimulates further increases in real housing prices. With further increases in expectations, the process of rising real prices continues until some other factor intervenes and dampens or reverses expectations. With the process reversing, the "bubble" can then burst in a crescendo of falling real housing prices.

Such a scenario seems to be implicit in many popular discussions of real-estate booms and crashes.[20] The relevance of "price bubbles" in asset markets has been questioned, however—on an empirical if not a theoretical level—by economists working within the framework of "rational expectations" theory.[21] Thus, we are led to conclude that the explanation for recent housing-market developments should be sought in changes in general inflation expectations, rather than separately formed housing expectations.

V. Empirical Analysis

Our analysis appears to offer a description of housing-market behavior that is consistent, in a very general way, with observed market trends. However, there are a number of advantages to exploring the implied relationships in a more rigorous way. First, since many other factors may influence the housing market, it would be useful to observe the significance of the statistical relationship between housing-market trends and inflation expectations. Second, empirical analysis might shed some light upon several unresolved theoretical issues. For example, does a representation of *general* inflation expectations satisfactorily explain housing prices and rent relationships, or is it necessary to add *housing* inflation expectations as well? Also, is "affordability" a factor in the behavior of the housing market?

Rental-price relationship

To explore these issues, we employ two relationships derived from the earlier discussion. The first is the equilibrium condition that real rents should equal owner-occupant housing costs, or

$$R = P((1-t)(r+z)-h+f)$$

which may be rewritten

$$R/P+h = (1-t)\,i+f$$

where f represents the effects of depreciation, maintenance, insurance and property taxes—assumed to be a constant proportion of the value of the stock. If overcoming a cash-flow constraint imposes costs on a household in proportion to the nominal interest rate, then

$$R/P+h = (1-t+a)i+f$$

where "a" is the cash-flow proportion. With the aid of regression analysis and information on i, h, and R/P, we can obtain estimates of f and the coefficient on i. We can then compare these estimates with *a priori* notions to obtain a crude indication of the consistence of the model with the data.

We estimated this linear relationship using quarterly data and two different classes of assumptions concerning the formation of housing-price inflation expectations. In the first model, we assumed that households expect housing prices to rise at the same rate as prices of goods overall. In the second model, we employed a separate variable, assuming that housing inflation expectations are formed adaptively. (See Appendix A for details on the construction of these measures.) Each model was estimated using both ordinary least squares (OLS) and a Cochrane-Orcutt technique for treating serially correlated errors.

Outside estimates of the marginal tax rate, t, suggest values in the .20 to .30 range and a figure of 5 to 7 percent for the fraction of real housing value represented by maintenance, depreciation, property taxes and other value-based components of user costs (Table 1).[22] On this basis, the first model performs quite well. The marginal tax rate (.27) and the maintenance factor (8.8) are quite precisely estimated and near the anticipated values, if we assume that the affordability constraint (measured by "a") is not significant.

The second model performs less well, in a statistical sense, and is sensitive to the estimation technique. In the Cochrane-Orcutt version, for example, the constraint term is indistinguishable from zero. More importantly, however, a large affordability constraint (that is, a large "a" coefficient) is necessary to yield reasonable tax-rate estimates. Thus, in this model at least, the finding of an affordability constraint is linked with the assumption of separately formed housing inflation expectations.[23] Since there is little empirical evidence to sup-

Table 1
Regressions on the Rental/Price Relationship, 1965.I to 1978.IV

			Regression Coefficients				Implicit Point Estimates	
Model	Housing Price Inflation Expectations Assumption	Estimation Technique	Constant	Nominal Interest Rate	R^2	D.W.	Tax Rate	Depreciation, Maintenance, et. al. (%)
1a.	Same as consumption prices in general	OLS	8.92 (15.42)	.722 (9.55)	.69	1.21	.28(+a)	8.9
1b.	Same as consumption prices in general	Cochrane-Orcutt	8.83 (9.31)	.734 (5.93)	.70	1.94	.27(+a)	8.8
2a.	Housing expectations formed separately	OLS	8.62 (3.60)	1.10 (3.53)	.41	1.06	−.10(+a)	8.6
2b.	Housing expectations formed separately	Cochrane-Orcutt	5.07 (0.92)	1.44 (2.14)	.54	1.90	−.44(+a)	5.0

NOTE: t-ratios are in parentheses. The dependent variable is R/P+h. The independent variable is a distributed lag on the nominal interest rate, i. See Appendix A for additional computational details.

port the existence of "speculatively" formed expectations in asset markets, we are inclined to reject the finding of an affordability constraint as well. In light of the combined evidence, therefore, there appears to be little support for the notion that housing inflation expectations are formed separately (at least as modelled), or that "affordability" is an important factor in the housing market.

Levels of prices and rents

The model also identified the factors that should affect the *levels* of real housing prices and real rents. In particular, under conditions of imperfectly elastic supply, real housing prices should be positively related to housing inflation expectations and household wealth, and negatively related to the interest rate, everything else being equal. We have argued that real rents, on the other hand, should behave in the same way as user costs. Thus, following our earlier arguments, rents should be negatively related to housing inflation expectations and positively related to wealth and the interest rate, everything else being equal.

These implications can be tested by regressing data on real housing prices and real rents, respectively, on measures of inflation expectations, the interest rate, and household wealth. However, a lagged measure of the housing stock, because of its probable sluggish adjustment, must also be included in the regression. Everything else being equal, a larger existing supply implies lower housing prices and rents.[24]

All of the signs of the estimated coefficients are consistent with the thesis we have presented under the assumed circumstances of imperfectly elastic supply (Table 2).[25] Increases in wealth per household (proxied by real disposable permanent income) cause both prices *and* rents to rise. Increases in the nominal interest rate decrease real housing prices but, as expected, cause real rents to rise as the resultant low prices cause reductions in the housing stock. The effect of capital-gains expectation is captured by the sign of the coefficient on inflation expectations. It indicates that increases in housing inflation expectations increase real housing prices, but reduce real rents as suppliers respond to high prices by adding more housing to the stock.

Finally, the significance of the coefficient on the lagged housing stock suggests that stock adjustment is, indeed, a sluggish process; the existing stock is an important determinant of current prices and rent levels. The coefficient has a negative sign, as expected, because increases in the existing stock reduce both real prices and rents, everything else being equal. Since the coefficient on the housing-stock variable in the long-linear regression can be interpreted as an elasticity, the real housing price apparently is quite responsive to changes in the existing stock. A one-percent change in the lagged stock supply results in over a two-percent change in the price. In a world in which the housing supply is imperfectly elastic and adjustment processes are sluggish, this is consistent with inelastic housing-stock demand.

Table 2
Price and Rent Regressions, 1965.I to 1978.IV
(all variables in log form)

	Constant	Nominal Interest Rate	Inflation Expectations	Permanent Income/Household	Lagged Real Housing Stock/Household	R^2	D.W.
1. PRICE	−7.9	−.30	.58	1.7	−2.8	.98	2.3
	(2.6)	(6.5)	(7.8)	(4.0)	(4.7)		
2. RENT	−1.0	.063	−.13	.55	−1.6	.99	1.6
	(1.0)	(1.6)	(5.26)	(4.0)	(8.0)		

NOTE: t-ratios presented in parentheses. See Appendix A for additional computational details.

VI. Policy Implications

Rising inflation expectations apparently have been closely involved in the recently observed pattern of rising housing prices, falling real rents, and—by implication—a shrinking rental-housing sector. However, we have found no evidence to suggest any similar separate influence of housing-price inflation expectations, as in models of speculative price bubbles. Similarly, trends in real rents suggest that "affordability" has had little if any impact on recent housing trends. A number of policy implications flow from these results and from our earlier discussion.

Housing crisis

Inflation has been at the root of many of the industry's recent changes—but this does not mean that inflation has caused a crisis in the form of unaffordable housing or unavailability of rental housing. In general, properly measured housing *costs* have fallen relative to other prices despite the rise in housing *prices*. The trend away from rental housing, including the conversion of rental housing to owner-occupancy status, represents a natural consequence of households' attempts to cope with the combined impact of inflation and tax regulation. Some communities have tried to address the "loss" of rental housing to condominiums by blocking conversions, but that "solution" actually reduces households' aggregate welfare, because it blocks their attempts to find the lowest-cost housing alternative.

Disparate tax treatment of the two types of property appears to be the basic cause of the shift away from rental housing in an inflationary era. The trend could be reversed, perhaps, if owner-occupants' implicit rental income were included in their taxable income, and if landlords' depreciation allowances reflected market rather than historic value. Public-finance economists have frequently proposed such changes on grounds of tax equity, but the political realities argue against their acceptance, especially in view of the longstanding policy commitment to encourage homeownership.

Nonetheless, the distortion by inflation on housing patterns is arbitrary and thus unlikely to be socially optimal. In addition, the distortion is not confined to choices within the housing market. The combination of inflation and special tax treatment tends to alter relative rates of return *within* housing, and also *between* housing and other assets in the economy. (In terms of tax treatment, incidentally, a landlord's housing investment is analogous to investment in general.) Thus, capital that otherwise would have flowed into industrial uses frequently has been attracted to housing instead. Trends in the composition of household portfolios verify a dramatic shift by households out of financial assets (including corporate equities) into housing assets.[26] Thus the true "crisis" may be that too much—rather than too little—housing is produced and consumed in our economy.

Inflation and the CPI

More indirectly, inflation's impact on housing aggravates a problem created by the incorrect treatment of housing in the consumer-price index. The appropriate measure of housing costs—that is, the measure that is relevant to demand and welfare analysis—is the opportunity cost or user cost of housing. Although this measure depends importantly on price expectations and is inherently impossible to observe directly, theory suggests that it should move with market rentals.

In contrast, CPI procedures developed in the 1950's to reflect homeownership costs confuse costs of *purchasing* the asset with various costs involved in holding the asset per period.[27] The consumer-price index currently employs weighted data on the price of new homes (part of the CPI's "home purchase" component) and mortgage interest costs (the component "contract mortgage interest costs"), in addition to property taxes, insurance, and maintenance and repair. The home-purchase and mortgage-interest components, with a weight of about 17 percent in the overall CPI, increase sharply in magnitude as inflation expectations rise. But as we have seen, this is exactly when real housing *costs* tend to fall. The current CPI procedures thus lead to severe overstatement of the contribution of housing to inflation.

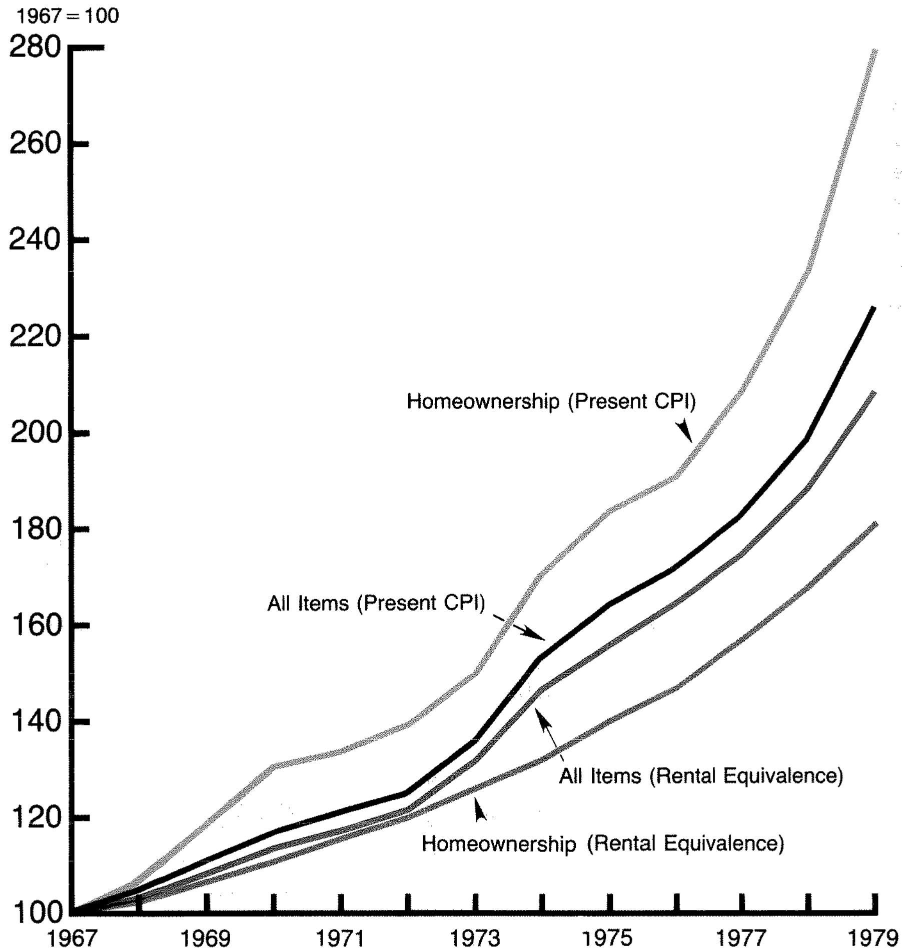
A conservative estimate of the overstatement can be derived from experimental "rental equivalence" measures developed by the Bureau of Labor Statistics.[28] The CPI apparently was at least 8 percent higher in 1979 than it should have been, due to overstatement of housing costs during the 1968-79 period (Chart 4). Considering the myriad public and private programs and contracts which use the CPI as an inflation index, such an overstatement itself has introduced inflation-related distortions into the economy.

Mortgage policy

Finally, some brief observations may be made concerning the relationship between mortgage instruments and the housing market. The general trends in the data and the simple regression analysis presented here are not consistent with the notion of severely binding cash-flow constraints on housing. However, our tests are admittedly weak, and it is impossible to say whether the standard fixed-payment mortgage and mortgage lenders' qualifi-

Chart 4

Alternative Housing Cost Measures and Inflation



cation standards are completely unimportant, or are simply overwhelmed by other factors. Policies to relieve the constraint—such as promoting graduated-payment mortgages or equity-sharing arrangements with lenders—should help cause housing demand to increase if the constraint has been at least somewhat binding. With given supply conditions, this should lead to an increase in the real price of housing, though not by enough to fully offset the reduced implicit costs of housing assets.

VII. Conclusion

In our analysis, rising inflation expectations—interacting with the tax treatment of housing—help account for several major recent trends in the housing market. Our emphasis on inflation expectations is not meant to deny the influence of other factors. Indeed, the maturing of the "baby boom" generation, local restrictions on new housing investment, and the proliferation of single-headed households all have contributed to rising real housing prices. However, the lack of evidence of any rise in user costs (as proxied by real market rents) suggests that such factors have not been the dominant force in stimulating rising housing prices. Moreover, our analysis suggests that the housing "crisis" is not one of widespread unavailability of housing at reasonable costs. On the contrary, inflation and the tax structure may have encouraged too great a commitment of resources to housing, and may have created further distortions because of the mismeasurement of housing costs in the CPI.

Appendix A
Computational Details

This study utilized quarterly U.S. data series throughout. The following is a list of the sources of the data, with manipulations performed as noted.

Price. A real housing-price index was constructed with the C-27 data of the U.S. Department of Commerce, which relate to the price of new one-family houses, including the value of the lots. This index is for a unit of fixed characteristics, and was deflated by the personal-consumption expenditures deflator.

Rent. A real rental index was constructed with the rental survey component of the consumer-price-index, deflated by the personal-consumption expenditures deflator.

General Inflation Expectations. A number of series were tested. The one employed in the regressions is from Scadding (1979), based on analysis of the inflation forecasting implicit in consumption behavior.

Housing Inflation Expectations. A number of series were tested. The one employed in Table 1 is an eight-quarter, third-degree polynomial distributed lag on the change in nominal housing prices.

Housing Stock. The real value of the housing stock per household was obtained from the Bureau of Economic Analysis (U.S. Department of Commerce) estimates of the value of fixed, residential capital in the U.S. The series is reported in the *Survey of Current Business*. This annual series was interpolated quarterly using the quarterly measure of the number of housing units.

Households. Annual data on the number of households is reported in the Bureau of the Census, Current Population Reports, Series p-20. Quarterly values were interpolated.

Nominal Interest Rate. The AAA corporate-bond rate is employed as a measure of the nominal interest rate. The mortgage rate was also tested, but a useful series could not be obtained because of variations in the features of the instrument over time. In addition, an open-market rate such as the AAA bond rate more accurately reflects the opportunity costs of housing equity.

Permanent Income. An estimate of permanent income per household was obtained with data on disposable personal income, and with an estimation method described in Darby (1974).

Rental/Price Ratio. The benchmark ratio of nominal rents and prices was obtained from data from the 1975 National Housing Survey. The rental-price index and the housing-price index reported above were used to complete the series.

Econometric Methods. All of the reported regression estimates were obtained with the use of ordinary least-square methods. An eight-quarter, third degree, unconstrained polynomial distributed-lag structure was employed on the components of the opportunity-cost variable in the regressions reported. This was done because the opportunity-cost variable should theoretically be entered separately for each period into the future; we have assumed that a household's forecast of these future values is contained in current and recent past estimates of the opportunity cost. (The regressions were also run using contemporaneous values only; the results were qualitatively similar.)

FOOTNOTES

1. See, for example, Feldstein, Green and Sheshinski (1978).

2. The best data are available for *new* housing only. However, theory would suggest that the prices of close substitutes (existing homes, for example) would move similarly. The available data suggest that this is, indeed, the case.

3. Increased quality accounts for approximately 15 percent of the increase in average sales prices of homes sold in the period 1970–79. The data on new housing prices and characteristics are available in U.S. Bureau of the Census Reports C-25 and C-27.

4. Data on housing tenure are available from the Current Population Survey of the Bureau of the Census. There is some lack of comparability between this relatively recent source of data and the decennial census that makes comparisons of tenure patterns over time difficult. Moreover, we are primarily interested in the **value-weighted** tenure share, to control for quality changes. One such attempt to create this type of data (published periodically in U.S. Department of Commerce, **Survey of Current Business**), also shows an acceleration in owner share, however.

5. See the Annual Housing Survey, General Housing Characteristics, Part A.

6. See, for example, S. Nicholson, "Rental Housing: Why Don't the Numbers Work?" **Building,** December 1979.

7. "Apartment Trends," **U.S. Housing Markets,** March 1980, p. 10, and **Rental Housing: A National Problem that Needs Immediate Attention,** Report to Congress by the Comptroller General, General Accounting Office, November 8, 1979, p. 11.

8. "Condo Conversions: '79's Boom Won't Bust," **Housing,** March 1980, p. 35, and "Apartment Trends," **U.S. Housing Markets,** September 1979, p. 10.

9. See, for example, N. Mayer (1977).

10. See, for example, A. Polinsky (1979).

11. See, for example, W. E. Diewert (1974). In the view taken here, wealth is considered to be an exogenous variable and therefore appears as an argument of the demand relationship. If wealth is viewed as endogenous, then the optimal stock of an asset depends only on opportunity costs if the asset's services are easily marketed. Hess (1977) tests and rejects the exclusion of wealth from asset-stock demand relationships.

Although, conceptually, opportunity costs for each period in the future are separately relevant to asset-stock demand, we assume that inflation expectations are constant over the entire planning horizon, and thus the entire time path can be represented by a single period's opportunity costs.

12. See, for example, Rosen and Rosen (1980).

13. Ignoring depreciation, a profit-maximizing landlord adds to his housing stock until after-tax rental income equals the (after-tax) cost of carrying the stock per period. That is, until

$$(1-t)R = ((1-t)(r+z) - (1-c)z)P$$

where t is the landlord's effective capital-gains tax rate. (Note the assumption, for simplicity, that $h=z$.) Thus

$$R = ((r+z) - z(1-c)/(1-t))P$$

relates the market rental and expectations. By comparison, owner-occupant opportunity costs are

$$U = ((1-t)r - tz)P$$

under similar conditions. Clearly, in the extreme case where capital gains are treated like ordinary income, $t=c$ and $\delta R/\delta z = 0$. That is, landlord costs are unaffected by inflation expectations. Even for lower capital-gains tax rates, however, landlord costs will not decline as much as owner-occupied housing costs as long as $t^2 \leq c$. The tax treatment of depreciation causes further offsets in the cost-reducing effect of rising inflation expectations, because the historic-cost basis of landlords' depreciation allowances causes the depreciation deduction to fall in real value as inflation rises. See, for example, de Leeuw and Ozanne (1979) and Feldstein, Green and Sheshinski (1978). In addition, a non-tax feature—the fear of rent control—may cause landlords to feel that their future income or capital gains are compromised by rising inflation. This may be an important factor in some markets and it is one that deserves separate attention; for simplicity, however, we treat these effects as an element of a "tax" policy toward rental housing since it, too, has the effect of making the breakeven rent less favorably sensitive to inflation expectations.

14. This approach is in sharpest contrast to that of Rosen and Rosen (1980), in which changes in tenure patterns are related to differences between the *equilibrium* levels of rents and opportunity costs. They do not detail the model which underlies their analysis, and it is not clear why rents and opportunity costs should not move together, although their empirical work assumes that this is the case.

15. A technical appendix describing a mathematical version of the model is available from the author.

16. A securely rising marginal tax rate and/or a falling real interest rate could also contribute to this effect. Indeed, these may represent additional avenues through which inflation-induced distortions can affect the housing market. Marginal tax rates can rise as the result of "bracket creep"—the effect of a progressive tax-rate structure applied to nominal income. Feldstein and Summers have also argued that inflation (coupled with tax policy) can reduce aggregate loan demand and, hence, the (real) interest rate. (See Feldstein and Summers, "Inflation, Tax Rules and the Long Term Interest Rate," **Brookings Papers on Economic Activity,** Volume 1, 1978.) Although these effects are not specifically addressed in this paper, they are consistent with the general notion that inflation-induced distortion, rather than income or demographics, is the primary factor behind relative price and rent movements in the housing market.

17. See, for example, the viewpoints cited in "Legislating to Restrain Coops and Condos," **Business Week,** February 18, 1980, p. 90–91.

18. The most careful study of "affordability" is Kearl (1979). However, Kearl attempts to measure the effects of "affordability" constraints by including the initial mortgage payment in his regressions. It is not clear that a useful proxy for this effect can be devised, since the true shadow price of the constaint is unobservable. In addition, the variable used by Kearl is highly correlated with the nominal mortgage rate, which would have the sign he finds in his analysis irrespective of affordability problems.

19. See A. Hess, "Credit conditions and Automobile Demand," University of Washington (mimeo), August 1976 and March 1980, revised. See also van Order and Villani (1979), who propose a less general form of constraint.

20. A recent popular version of this hypothesis is presented in Cardiff and English (1979).

21. See, for example, R. Flood and P. Garber, "Market Fundamentals versus Price-Level Bubbles: The First Tests," **Journal of Political Economy,** September, 1980.

22. This is the range of tax rates implicit in the relative rates of return of taxable and non-taxable securities of similar quality, as well as the tax on interest income, estimated using Colin Wright's technique from IRS statistics. (See Colin Wright in Harberger, 1969.) The real-estate industry uses an estimate of one percent of market value each for maintenance and depreciation, although a higher figure for both is probably justifiable. (See Laidler in Harberger, 1969) Property taxes average 2.5 percent of market value. Insurance and expected uninsurable losses likely add less than one percent. Finally, in the context of our model, transactions costs and any costs due to the "liquidity" of the housing asset must be added to these other components.

23. Indeed, the fact that Kearl (1979) employs this assumption and finds an affordability constraint may be related.

24. The model may be solved for the absolute level of real housing prices and rents by making some assumptions about supply conditions. That is, we have assumed that prices move to equate the stock demanded with the available total stock, or to preserve

$$D(U,W) = D(R,W) = K,$$

where K is the available housing stock. However, K is not fixed, but rather is itself a function of real housing prices. Specifically, if one imagines the housing industry responding with a lag to changes in the real price,

$$K - K_{-1} = d(K^*(P) - K_{-1})$$

where K^* is the long-run stock supply implied by the current real price and d is a constant or function denoting the relationship between actual and long-run changes in the stock. Thus in general the supply relationship may be written

$$K = K(P,K_{-1})$$

and P may, in principle, be derived from the solution of stock demand and this supply condition or,

$$P = P(u, W, K_{-1}) = P(i, z,W, K_{-1}).$$

Similarly, R may be determined as

$$R = R(P, W, K_{-1}) = R'(u, W, K_{-1}) = R'(i, z, W, K_{-1}).$$

25. If supply were perfectly inelastic (with respect to the real price), increases in the interest rate would depress real prices, but not affect market rentals; conversely, if supply were perfectly elastic, an increase in the mortgage rate would not affect the real price but would depress real rentals. Our finding that both are affected is consistent with the notion of imperfectly elastic supply.

26. See Kane (1980).

27. The method of constructing the housing component is detailed in "Housing Costs in the CPI," **Monthly Labor Review,** February 1956, pp. 184–196.

28. Janet Norwood, "The Consumer Price Index Puzzle," **Challenge,** March–April, 1980, pp. 41–45, Tables 1 and 2. This is conservative because the weights employed in the "rental equivalence" series are based on expenditures and do not incorporate capital-gains effects on income.

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