**Purchases of Structures in LIFT**

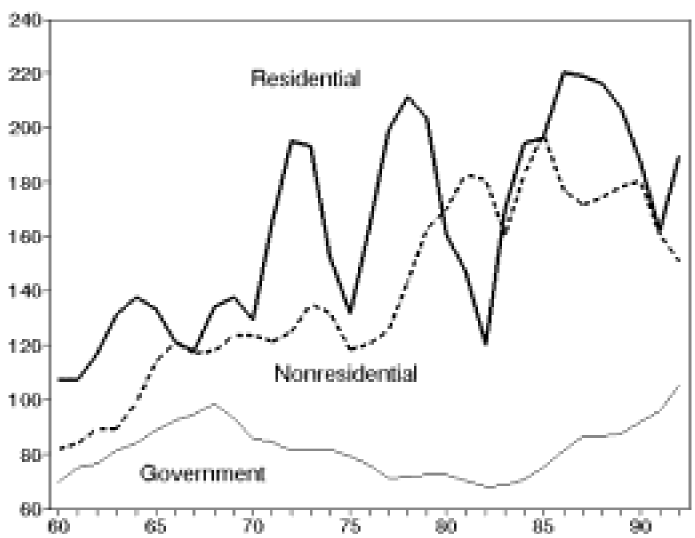
Lorraine Sullivan Monaco

An important source of activity in the economy is construction of houses, stores, highways, schools and other structures. Because it is labor-intensive, construction activity directly affects employment in the economy. In addition, construction activity creates demand for supplies from other industries. For instance, residential construction spurs demand for not only building materials, such as bricks and lumber, but also furnishings, such as draperies, appliances, and furniture. Highway construction, on the other hand, creates demand for heavy equipment and concrete. Rather than forecast aggregate construction activity, LIFT specifies purchases of thirty-one types of structures. (The thirty-one sectors correspond to categories in the National Income and Product Accounts.) This paper describes the most recent estimation of equations for purchases of structures by type, as well as the forecast of construction from Inforum's December 1993 outlook.

## Overview

Figure 1 illustrates the three principal types of structures investment: Residential, such as homes and apartment buildings, Nonresidential, such as office buildings and pipelines, and Government, such as military barracks and highways. Residential investment is the largest and most cyclical type of structures investment. Nonresidential investment, while almost as large as residential, has a much less volatile history. Investment in public structures averaged about 20% of total purchases of structures from 1960 to 1992, and does not display the same volatility of

Figure 1
Purchases of Structures
Residential, Nonresidential & Government
billions of 1987 $



private investment.  After declining almost continuously from 1969 through 1985, purchases of Government structures have grown by 5.6% per year since 1985, largely due to increases in highway construction and public educational facilities.[1]

Although equations are estimated separately for each type of private investment, all of the equations rely on four principal concepts.  (See Table 1 for a summary of the equations.)  First, each equation contains some measure of demand.  Residential structures depend on current and lagged values of personal disposable income, for example, while nonresidential structures depend on industry production.  For instance, as manufacturing output increases, demand for new factories (Industrial structures) rises.  A second influence on purchases of structures is the existing stock of structures, or the depreciation of that stock.  An increase in demand for office space may not result in increased construction of offices, if the existing stock of office buildings is sufficiently large.  On the other hand, new office buildings may need to be purchased even in the face of slow demand for offices, in order to replace old offices that are depreciating.  Demographic variables also are used to explain purchases of structures, and are especially important in a long-run forecasting model.  For instance, purchases of single-family homes decline relative to apartment buildings when the population consists of fewer young families and more elderly households.  While that trend may not influence residential construction on a quarterly basis, it will be important over a ten-year forecast.  Finally, another important variable in explaining structures is interest rates, such as the mortgage rate for residential investment.

Table 1: Influences on Structures in LIFT

| Residential Structures<br>Sector<br>Number and Title | Disposable Income | Mortgage Rate | % of Hhlds Home-buying Age | Other |
|---|---|---|---|---|
| 1 Single-family units | + | - | + | Regulation Q interest rate differential |
| 2 Multi-family units | + | - | - | Tax shelter dummy |
| 3 Mobile homes | | + | | Personal consumption expenditures |
| 4 Additions/alterations/replacements | + | - | + | % resid structures that are single-family units |
| 31 Brokers' commissions | + | - | + | |

| Nonresidential Structures<br>Sector<br>Number and Title | Industry Output | Rate | Interest Stock | Other | |
|---|---|---|---|---|---|
| 5 Hotels/dorms | | | - | - | Highway construction, Personal income |
| 6 Industrial structures | + | | - | - | |
| 7 Offices | + | | - | | Employees/Stock of Structures in services |
| 8 Stores, restaurants, garages | + | | | - | Residential structures |
| 10 Private education | | | | | School-age population, Personal consumption |
| 11 Private hospitals | + | | | | Public hospitals, Elderly popul., Medicaid |
| 12 Misc. nonresidential structures | | | - | | Store construction, Highway construct, Popul. |
| 13 Farm construction | + | | - | | Relative price of agricultural products |
| 14 Mining/oil wells | + | | - | | Relative price of oil |
| 15 Railroads | + | | - | | Highway construction, Relative price of oil |
| 16 Telephone/telegraph | | | - | | Residential structures, Offices, Stock wear-out |
| 17 Electric utilities | + | | - | | Growth in number of households |
| 18 Petroleum pipelines | + | | - | | Coal output, dummy variable |
| 19 Other private structures | | | | | Highway construction, Personal consumption |
| 27 Public education | | | | - | School-age population |

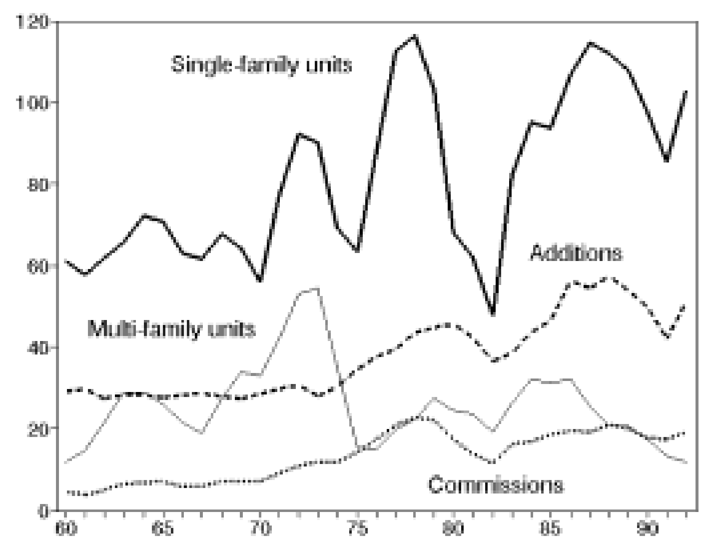
[1] Government structures are, for the most part, exogenous in LIFT.

Residential Structures

As illustrated in Figure 1, residential structures are the largest and most volatile type of structures investment. Part of this volatility in the 1960s and 1970s was due to this sector's sensitivity to monetary policy stemming from an interest-rate ceiling regulation. Regulation Q placed a limit on the interest rates that could be paid by banks and savings-and-loan associations. Given a rise in market interest rates above the Regulation Q level, investors withdrew money from banks and S&L's in favor of other investments which yielded the higher interest rate. Since banks and S&L's finance most construction, this withdrawal of funds led to a cutback in residential construction.

The largest component of residential structures, and the most volatile, is Single-family units. (See Figure 2) The equation for single-family units combines demand, demographic variables, and interest rate effects, as well as a variable to explain the effects of Regulation Q. The Regulation Q variable is the difference between long and short interest rates from 1962 to 1982, when Regulation Q was rescinded. (After 1982, the Regulation Q variable is zero.) When this variable was large, banks and S&Ls could offer competitive rates to attract investors and still charge an interest rate below the regulated level, and residential construction would increase. When the variable was very small, or negative, investors would flee bank investments in favor of investments which yielded higher interest rates, reducing residential construction.

Figure 2
Residential Structures
billions of 1987 $



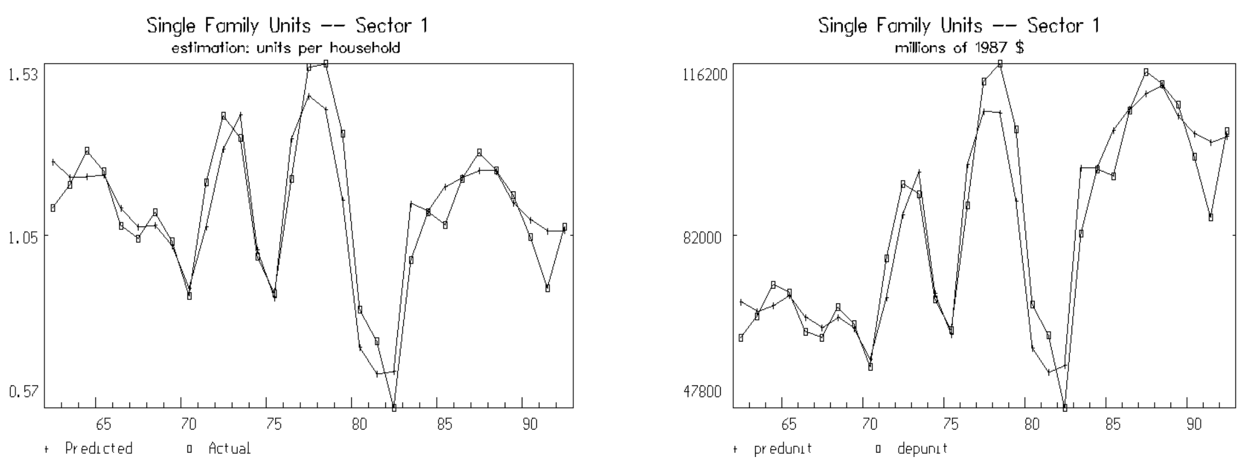
One reason residential structures may increase over time is simply because population is increasing. Even if there is no change in economic behavior, structures will rise when population rises. To ensure that the equation explains behavioral reasons for changes in structures, the dependent variable is calculated as single-family units per household. As shown in the first graph in Figure 3, single-family units per capita actually exhibit a slight downward trend from 1962 through 1992. Purchases of single-family homes depend positively on current income and current and lagged changes in income. In addition, purchases of single-family homes respond negatively to increases in mortgage rates. An increase of one percentage point in the mortgage rate decreases purchases of new structures by 7.3%. Purchases of single-family homes also depend positively on the number of households in the prime home-buying age. The variable used is the percent of households in the U.S. where the head of household is between the ages of 25 and 35 years old.

Figure 3
Estimation Results: Single-family Units

```
                    Single Family Units -- Sector 1

   SEE   =       0.08 RSQ   = 0.8319 RHO =    0.36 Obser  =    31 from 1962.000
   SEE+1 =       0.08 RBSQ  = 0.7899 DW  =    1.27 DoFree =    24 to   1992.000
   MAPE  =       6.23
```

| | Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|---|
| 0 | single-family/household | - - - - - - - | - - - - | - - - - | - - - | - - - - | 1.12 |
| 1 | intercept | 0.10933 | 0.4 | 0.452 | 0.10 | 5.95 | 1.00 |
| 2 | disposable income/household | 21.70167 | 1.9 | 0.966 | 0.26 | 5.94 | 0.01 |
| 3 | change in disp inc/hhld | 132.88278 | 5.6 | 1.665 | 0.02 | 4.63 | 0.00 |
| 4 | change in disp inc/hhld[1] | 175.93150 | 11.2 | 2.383 | 0.03 | 4.07 | 0.00 |
| 5 | mortgage rate | -0.08160 | 38.8 | -4.717 | -0.65 | 2.97 | 8.88 |
| 6 | Regulation Q | 0.08619 | 36.7 | 4.568 | 0.04 | 1.30 | 0.47 |
| 7 | % of hhlds of home-buying age | 0.06583 | 14.0 | 2.677 | 1.21 | 1.00 | 20.54 |




The second largest component of residential structures is Additions and alterations.[2] The equation for additions is similar in form to the equation for single-family structures. Purchases

[2] Specifically, this sector includes Additions, alterations, and major replacements for residential and nonresidential structures. Its largest component by far, however, is additions to residential structures.

of additions depend positively on income, negatively on interest rates, and positively on the number of households in the home-buying years. In addition, alterations respond positively to the share of total single-family units in total residential structures. In other words, homeowners are more likely to add on to a single-family unit than to an apartment or condominium. Many attempts were made to incorporate some sort of stock or replacement variable in the equation, but no specification resulted in reasonable coefficients. In addition, the idea that additions and alterations might be counter-cyclical was investigated. It seems reasonable to assume, for instance, that instead of purchasing a new home when the economy is doing poorly, repairs or additions would be made to existing homes. However, while there probably is some counter-cyclical activity in total additions and alterations, it is outweighed by the cyclical response to income and interest rates.

Figure 4
Estimation Results: Additions/alterations

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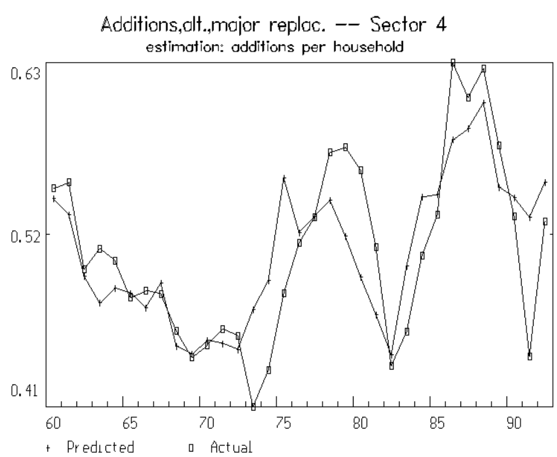
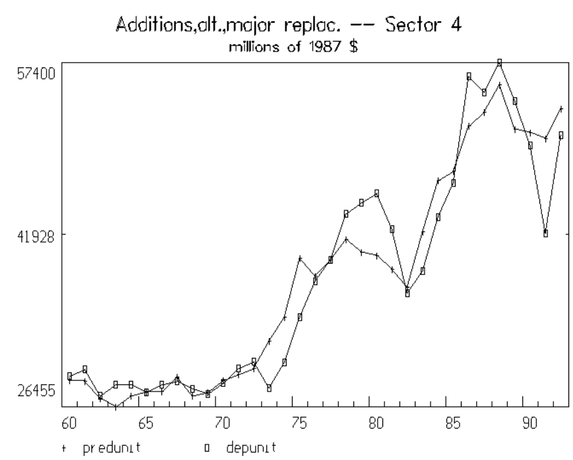
                 Additions,alt.,major replac. -- Sector 4

 SEE   =        0.04 RSQ   = 0.6076 RHO =   0.57 Obser  =   33 from 1960.000
 SEE+1 =        0.03 RBSQ  = 0.5350 DW  =   0.86 DoFree =   27 to   1992.000
 MAPE  =        5.35
```

| Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|
| 0 additions/household | - - - - - - - - - - - - - - - - - - - - - | | | | | 0.51 |
| 1 intercept | -0.11576 | 2.5 | -1.158 | -0.23 | 2.55 | 1.00 |
| 2 change disp income/hhld | 36.85825 | 2.4 | 1.139 | 0.01 | 2.55 | 0.00 |
| 3 mortgage rate | -0.02561 | 19.7 | -3.420 | -0.43 | 2.53 | 8.64 |
| 4 Regulation Q | -0.01580 | 7.9 | -2.107 | -0.01 | 2.53 | 0.48 |
| 5 % of hhlds of home-buying age | 0.03472 | 23.8 | 3.792 | 1.38 | 1.09 | 20.40 |
| 6 single fam share of resident | 0.00187 | 4.2 | 1.521 | 0.28 | 1.00 | 75.85 |




The third largest component of Residential structures is multi-family units (mostly apartments and condominiums). As with the equation for single-family units, multi-family dwellings are estimated in per household terms, and the equation uses disposable income, the mortgage rate, and a demographic variable. Multi-family dwellings respond positively to changes in income over two years, and negatively to increases in the real mortgage rate. In addition, the equation captures the effect of changes in the age structure of the population. As the percent of households in the prime home-buying years increases, purchases of multi-family dwellings decline. In other words, demand for apartment buildings increases as the share of elderly households increases. The equation also uses a dummy variable to capture an investment boom in the early 1970s due to the existence of tax shelters for investors in apartment buildings.

Figure 5
Estimation Results: Multi-family Units

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                          Multi-family Units -- Sector 2

  SEE   =       0.08 RSQ   = 0.7685 RHO =   0.67 Obser  =   33 from 1960.000
  SEE+1 =       0.06 RBSQ  = 0.7256 DW  =   0.67 DoFree =   27 to   1992.000
  MAPE  =      23.55

  Variable name                  Reg-Coef  Mexval t-value  Elas   NorRes      Mean
0 multi-family/household       - - - - - - - - - - - - - - - - - - - - -      0.37
1 intercept                     0.66977    25.0   3.899   1.83    4.32       1.00
2 change disp inc/hhld        162.72279     9.4   2.306   0.07    3.92       0.00
3 change disp inc/hhld[1]     122.02480     6.1   1.849   0.05    3.52       0.00
4 % of hhlds of home-buying age -0.01763    7.0  -1.979  -0.98    3.01      20.40
5 tax shelter dummy             0.21138    64.1   6.760   0.10    1.02       0.18
6 real mortgage rate           -0.00717     1.0  -0.733  -0.08    1.00       3.92
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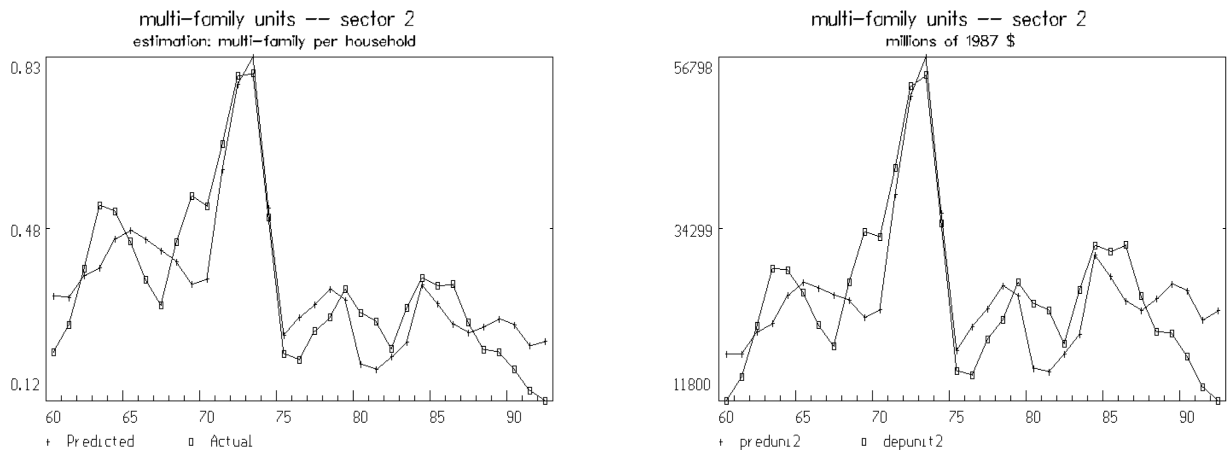


Another important part of total residential purchases is the amount spent on Brokers' commissions.[3] Since these are commissions on all real estate transactions, this variable responds to changes in new construction, as well as to increased sales of existing structures. In the mid-1970s, when changes in tax laws made real estate transactions favorable, there was a boom in commissions. Overall, there has been an upward trend in commissions per household since 1960. The variables used to explain commissions are similar to the variables used to explain the other types of residential structures. Commissions depend positively on personal disposable income and negatively on the real mortgage rate. In addition, commissions increase as the percent of the population of home-buying age increases.

Figure 6
Estimation Results: Brokers' commissions

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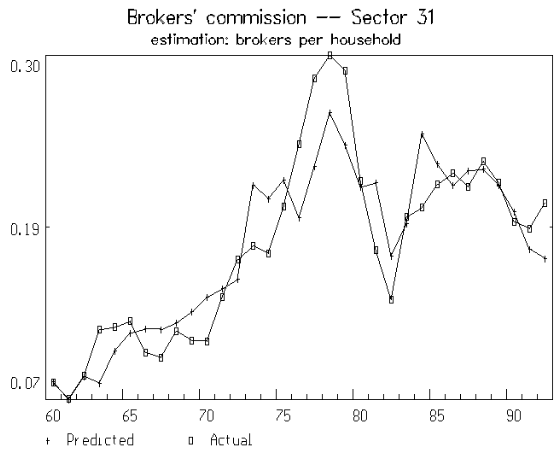
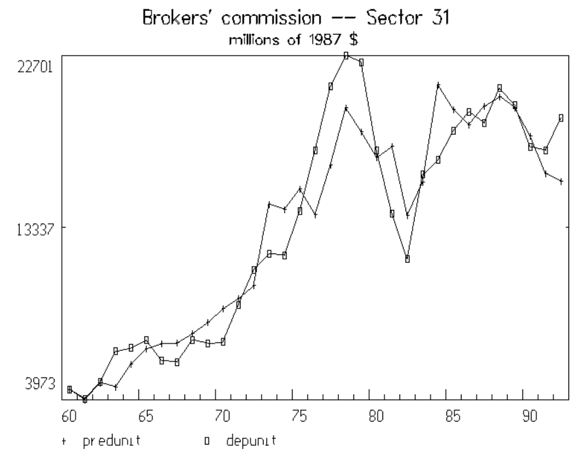
[3] Specifically, this variable includes commissions on residential and nonresidential structures, as well as net purchases of used structures. Residential commissions far outweigh the other components.

Brokers' commission -- Sector 31

| | | | | | | |
|---|---|---|---|---|---|---|
| SEE = | 0.03 | RSQ = 0.8014 | RHO = 0.50 | Obser = 33 | from 1960.000 | |
| SEE+1 = | 0.02 | RBSQ = 0.7647 | DW = 1.00 | DoFree = 27 | to 1992.000 | |
| MAPE = | 11.68 | | | | | |

| Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|
| 0 commissions/household | - - - - - - | - - - - | - - - - | - - - | - - - | 0.17 |
| 1 intercept | -0.40603 | 69.2 | -7.090 | -2.35 | 5.04 | 1.00 |
| 2 real disp income/hhld | 12.27094 | 9.0 | 2.260 | 0.92 | 2.28 | 0.01 |
| 3 change in disp inc/hhld | 62.81267 | 12.6 | 2.693 | 0.06 | 2.27 | 0.00 |
| 4 change in disp inc/hhld[1] | 35.91028 | 4.8 | 1.631 | 0.03 | 2.27 | 0.00 |
| 5 real mortgage rate | -0.01347 | 30.2 | -4.330 | -0.30 | 1.97 | 3.92 |
| 6 % of hhlds of home-buying age | 0.02239 | 40.3 | 5.115 | 2.64 | 1.00 | 20.40 |



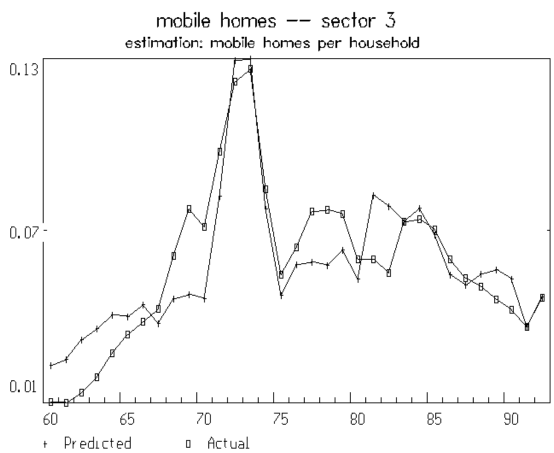

The final type of residential structure is purchases of Mobile homes, which are, in many instances, a substitute for purchases of a new home. The mortgage rate consequently has a positive effect on mobile home purchases. The demand variable for this sector is total personal consumption expenditures. As PCE per household increases, purchases of mobile homes likewise will rise. Finally, the equation uses the same tax shelter dummy used to explain multi-family dwellings, since the data show a similar bulge in spending in the early 1970s.

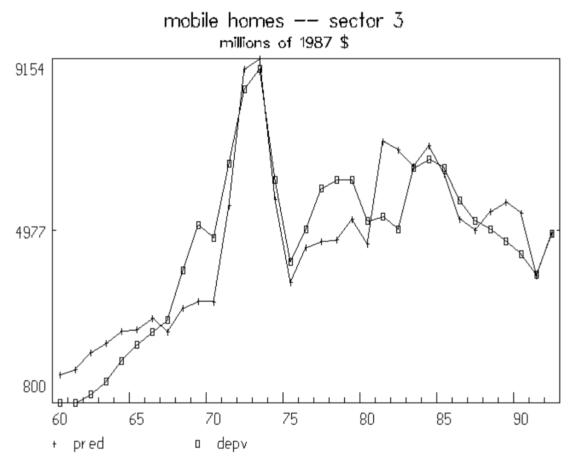
Figure 7
Estimation Results: Mobile homes

Mobile Homes -- Sector 3

```
SEE    =       0.01 RSQ   = 0.7687 RHO =   0.72 Obser  =   33 from 1960.000
SEE+1  =       0.01 RBSQ  = 0.7357 DW  =   0.55 DoFree =   28 to   1992.000
MAPE   =      24.20
```

| | Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|---|
| 0 | mobile homes/household | - - - - - | - - - | - - - | - - - | - - - | 0.06 |
| 1 | intercept | -0.00024 | 0.0 | -0.023 | -0.00 | 4.32 | 1.00 |
| 2 | change in PCE/hhld | 14.26188 | 11.6 | 2.622 | 0.08 | 4.28 | 0.00 |
| 3 | real mortgage rate | 0.01012 | 11.0 | 2.552 | 1.40 | 3.57 | 8.64 |
| 4 | real mortgage rate[1] | -0.00438 | 2.4 | -1.172 | -0.60 | 3.53 | 8.52 |
| 5 | tax shelter dummy | 0.04025 | 87.8 | 8.413 | 0.12 | 1.00 | 0.18 |



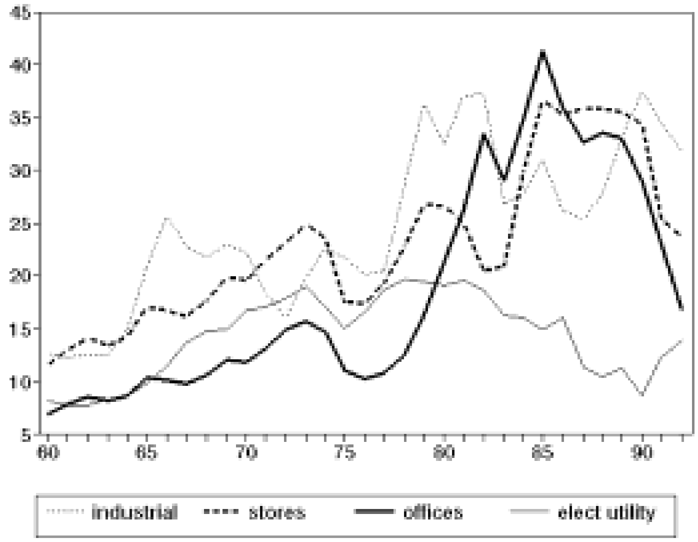




<u>Nonresidential Structures</u>

Nonresidential structures includes purchases of buildings, such as offices and stores, as well as other structures, such as pipelines and railroads. Although not as volatile as residential structures, the nonresidential sector clearly exhibits cyclical activity. The four largest types of nonresidential structures are illustrated in Figure 8: Industrial structures, Stores, restaurants and garages, Office buildings, and Electric utilities, and the equations for these sectors are described first.

Industrial structures, or factories, are one of the largest types of nonresidential construction. They are explained fairly well using an equation that combines lagged manufacturing output, the stock of industrial structures, and an interest rate variable. Since a short-term increase in output does not necessarily warrant the construction of a new factory, manufacturing output lagged one

Figure 8
Major Nonresidential Structures
billions of 1987 $




and two years is used in the equation.[4] The lagged stock of factories has a negative effect on new construction; the more stock currently available, the less new construction will be needed. Since industrial structures have a significant upward trend over time, the level of interest rates in 1992 are a much smaller share of those structures than in 1960. In other words, since interest rates do not exhibit an upward trend, their linear relationship with structures declines over time. To counteract that problem, a special interest rate term was computed as the product of the real corporate bond rate and the stock of structures. Allowing the interest rate to move with the stock of structures imparts some sector-specific trend to interest rates. Lagged increases in this interest rate term have the expected negative effect on industrial structures.

Another large nonresidential sector is Stores, restaurants and garages. These structures most often are located near residential centers, and the equation uses total residential construction as an explanatory variable. A one percent increase in residential structures implies almost half of a percent increase in stores in the following year. Demand for stores also responds to output of Wholesale and Retail trade, and Eating and drinking establishments. Finally, the lagged stock of stores, restaurants, and garages has the expected negative effect on current purchases of stores.

The equation fits fairly well, the adjusted r-squared equals .8543, although the growth period before 1982 is overestimated, and the boom from 1985 to 1990 is underestimated. In addition, the equation does not do well at predicting the last two years of historical data, 1991 and 1992, where it underestimates the effect of the recession. Attempts were made to include some

[4] LIFT specifies approximately forty manufacturing industries, so total manufacturing output is the sum of those forty sectors. An attempt was made to weight the outputs by structures/output ratios computed for one year. The improvement in the equation results was minimal, however.

measures of the overall business cycle in the equation, such as changes in employment or changes in GDP, but no equation produced more satisfactory results.

Figure 9
Estimation Results: Industrial Structures

Industrial Structures -- Sector 6

```
SEE   =     3770.99 RSQ   = 0.7514 RHO =    0.65 Obser  =   33 from 1960.000
SEE+1 =     2865.78 RBSQ  = 0.7158 DW  =    0.69 DoFree =   28 to   1992.000
MAPE  =       12.77
```

| | Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|---|
| 0 | industrial structures | - - - - - - - - - - - - - - - - - - - - - | | | | | 24654.55 |
| 1 | intercept | -6335.29244 | 4.9 | -1.679 | -0.26 | 4.02 | 1.00 |
| 2 | manufacturing output[1] | 13.77862 | 4.9 | 1.684 | 1.08 | 1.08 | 1934.65 |
| 3 | manufacturing output[2] | 10.00735 | 1.4 | 0.895 | 0.77 | 1.07 | 1891.25 |
| 4 | stock of industrial[1] | -0.03036 | 1.2 | -0.811 | -0.59 | 1.00 | 476088.67 |
| 5 | trended real raaa[1] | -0.07681 | 0.0 | -0.077 | -0.01 | 1.00 | 1788.70 |

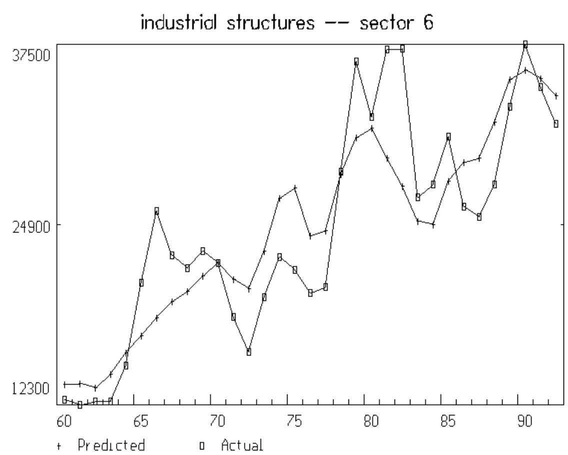


Figure 10
Estimation Results: Stores, Restaurants, and Garages

Stores, Restaurants -- Sector 8

```
SEE   =     2614.56 RSQ   = 0.8725 RHO =   0.70 Obser  =   33 from 1960.000
SEE+1 =     1948.24 RBSQ  = 0.8543 DW  =   0.60 DoFree =   28 to   1992.000
MAPE  =        8.57
```

| | Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|---|
| 0 | stores | - - - - - - - - - - - - - - - - - - - - - - - - | | | | | 22889.71 |
| 1 | intercept | 4275.72851 | 1.3 | 0.863 | 0.19 | 7.84 | 1.00 |
| 2 | stock of stores[1] | -0.09024 | 9.2 | -2.327 | -1.75 | 2.58 | 443804.50 |
| 3 | residential structures[1] | 0.10431 | 24.0 | 3.878 | 0.48 | 1.52 | 106315.15 |
| 4 | wh & retail trade output | 53.86798 | 7.8 | 2.136 | 1.76 | 1.00 | 748.89 |
| 5 | wh & retail trade output[1] | 9.94821 | 0.2 | 0.344 | 0.32 | 1.00 | 727.17 |

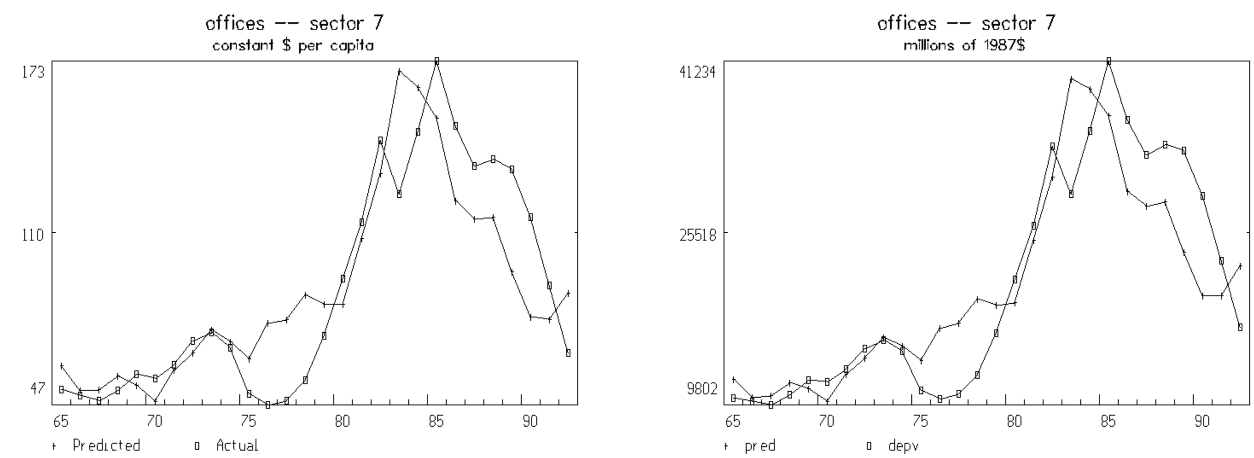
The third-largest nonresidential sector, Office buildings, experienced almost uninterrupted growth from the recession of 1976 to 1985, averaging 17.5% per year. Since 1985, it has declined at almost the same rate, 11.5% per year. The build-up of office construction occurred partly in response to growth of service industries, and partly in response to changes in tax laws that made it lucrative to invest in office buildings. The build-up through 1985 partly went to serving demand for offices, but also partly created a glut of unused office space. This over building set the stage for the last seven years of decline. The equation uses the ratio of employees in services to the stock of offices as a proxy for a "floorspace" variable. Although a distributed lag pattern was tried for this variable, the most reasonable results were obtained using a 4-year lag of the ratio. The employee to stock ratio lagged six years gave the best fit of the equation. That equation was not used, however. The coefficients on other variables were unreasonable, and six years was judged (subjectively) to be too long a lag for the model. Office construction also is explained by the growth in the output of service-related industries. In addition, increases in the interest rate decrease office construction. The equation fits modestly well, with an adjusted r-squared of .7003. For the most part, the large build-up and subsequent decline of office construction is captured.

Figure 11
Estimation Results: Office Buildings

Offices -- Sector 7

```
   SEE   =      20.06 RSQ   = 0.7336 RHO =   0.59 Obser  =   28 from 1965.000
   SEE+1 =      16.34 RBSQ  = 0.7003 DW  =   0.81 DoFree =   24 to   1992.000
   MAPE  =      19.06
```

| | Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|---|
| 0 | offices/population | - - - - - - - - - - - | - - - | - - - | - - - | - - - | 89.04 |
| 1 | intercept | -276.30222 | 42.6 | -4.980 | -3.10 | 3.75 | 1.00 |
| 2 | change in service output | 0.24149 | 5.7 | 1.672 | 0.13 | 2.89 | 46.95 |
| 3 | service employ/stock[4] | 9.91416 | 61.0 | 6.181 | 3.98 | 1.02 | 35.75 |
| 4 | change in raaa | -3.20078 | 1.2 | -0.746 | -0.00 | 1.00 | 0.13 |



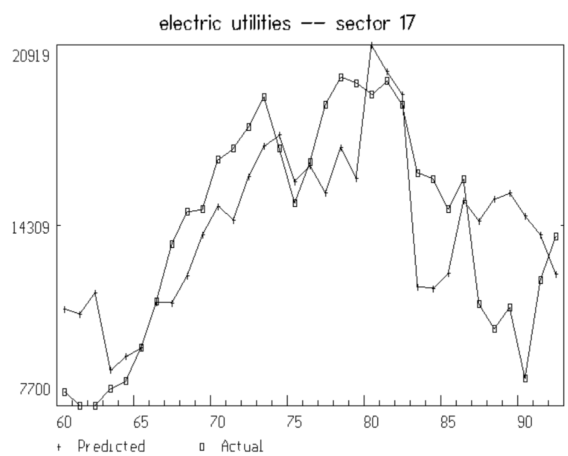

The graph of Electrical utilities construction in Figure 12 shows a build-up from 1960 to the mid-1970s, and then a decline from 1980 to 1990. In the last two years, construction of electric utilities has been rising again. The equation uses a combination of demographic, production, and interest rate variables. Since demand for electricity is related to overall population, the change in the number of households was found to be useful. Plans to build electric plants often are partly based on projections of population trends. Instead of using "future change in households" as an explanatory variable, the three-year average of the percent change in the number of households was used. This average can be thought of as a crude forecast of expected changes in population. In addition, the output of the electric utility industry also explains changes in construction of electric plants. As in the equation for Industrial structures, a trended real interest rate is used in this equation. The real interest rate is multiplied by the stock of utilities, and the lagged value of the variable has the expected negative relationship with structures.

Figure 12
Estimation Results: Electric Utilities

Electric utilities -- Sector 17

```
SEE   =    2631.70 RSQ   = 0.5497 RHO =   0.69 Obser  =   33 from 1960.000
SEE+1 =    1969.58 RBSQ  = 0.5031 DW  =   0.63 DoFree =   29 to   1992.000
MAPE  =      17.55
```

| | Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|---|
| 0 | electric utilities | - - - - - - | - - - | - - - | - - - | - - - | 14275.76 |
| 1 | intercept | -2224.96301 | 0.9 | -0.706 | -0.16 | 2.22 | 1.00 |
| 2 | 3yr avg of % ch in hhlds | 5334.10831 | 23.4 | 3.890 | 0.72 | 1.64 | 1.92 |
| 3 | real output of utilities | 0.05677 | 17.4 | 3.314 | 0.45 | 1.00 | 113670.43 |
| 4 | trended real raaa[1] | -0.08368 | 0.1 | -0.182 | -0.01 | 1.00 | 2240.28 |

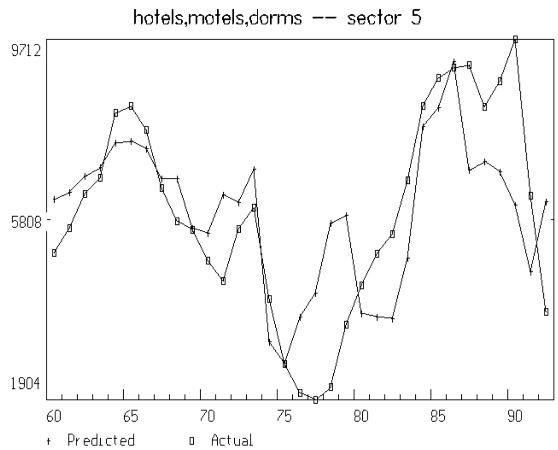



The next set of equations includes the remaining nonresidential sectors, and they are described in order of their sector numbers (as shown in Table 1). Construction of Hotels, motels, and dormitories is explained by a combination of demand variables and interest rate effects. First, hotel construction is correlated with highway construction; a one percent increase in highways leads to a one and a half percent increase in hotel construction (see the elasticities, located in the column labeled "Elas"). Second, demand for hotels is linked to tourism, which is affected by income. When personal income rises above its four-year average, hotel construction rises. The lagged stock of hotels fit well in the equation, and has the expected negative effect on new construction of hotels. Finally, an increase in the AAA-rated bond rate also has a negative effect on hotel construction.

Figure 13
Estimation Results: Hotels, Motels, Dormitories

```
                     Hotels, motels, dorms -- Sector 5

    SEE   =    1527.45 RSQ   = 0.5025 RHO =   0.62 Obser  =   33 from 1960.000
    SEE+1 =    1229.23 RBSQ  = 0.4314 DW  =   0.77 DoFree =   28 to   1992.000
    MAPE  =      27.98
  Variable name              Reg-Coef  Mexval t-value   Elas   NorRes     Mean
0 hotels                     - - - - - - - - - - - - - - - - - - - -   5967.00
1 intercept                5552.83712     6.4   1.921   0.93     2.01      1.00
2 highways                    0.36297    25.3   3.994   1.53     1.79  25181.82
3 chnge in income from avg   51.99194    25.0   3.967   0.62     1.40     71.10
4 chnge in interest rate   -331.70596     1.9  -1.041  -0.01     1.31      0.11
5 stock of hotels[1]         -0.04386    14.3  -2.934  -2.08     1.00 282383.62
```




Unlike other types of construction, Private educational facilities are not highly cyclical, but rather are dominated by long-term trends. The equation uses an estimate of future school-age population, plus total Personal Consumption Expenditures as a measure of demand. This simple equation explains construction of private schools reasonably well. The equation for Public educational facilities is similar to the one for private schools, in that the equation uses a measure of the school-age population. In addition, construction of public schools depends negatively on the current stock of public schools.

The equation explaining construction of Private hospitals relies on several different estimates of demand. First, the output of the Hospital sector affects construction over a three year period. Specifically, the percent change in hospital output currently and lagged twice are used in the equation. In addition, as the population ages, demand for hospitals increase. An increase in the

Figure 14
Estimation Results: Private Education

```
                     Private education -- Sector 10
    SEE   =     388.63 RSQ   = 0.8150 RHO =   0.58 Obser  =   33 from 1960.000
    SEE+1 =     323.50 RBSQ  = 0.8026 DW  =   0.84 DoFree =   30 to   1992.000
    MAPE  =      12.59
  Variable name              Reg-Coef  Mexval t-value   Elas   NorRes     Mean
0 education                  - - - - - - - - - - - - - - - - - - - -   2687.88
1 intercept              -17973.67510   106.1  -9.873  -6.69     5.40      1.00
2 est of future school-age  482.32708   132.4  11.491   6.66     3.19     37.10
3 personal consumption        1.25106    78.5   8.100   1.03     1.00   2211.76
```

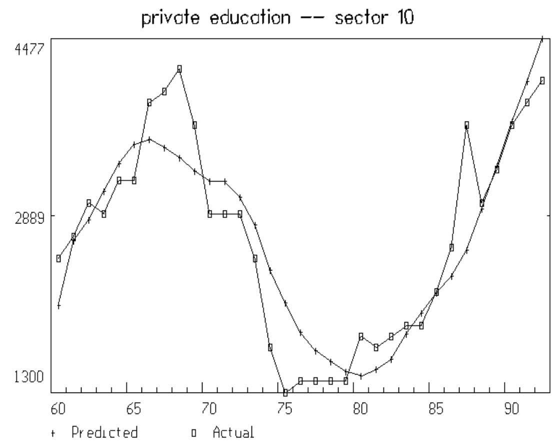
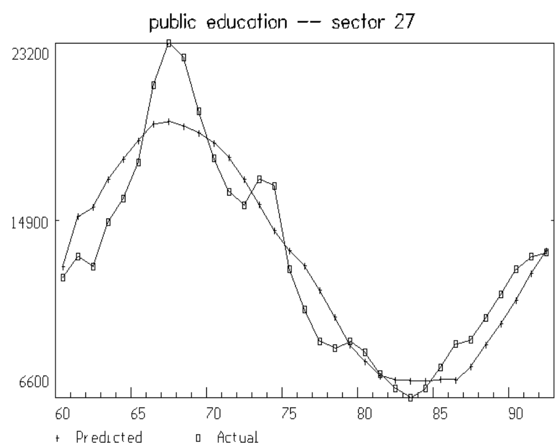



Figure 15
Estimation Results:
Public Education

```
    Public   Education   --
Sector 27
          SEE   =     1592.66 RSQ   = 0.8779 RHO =   0.71 Obser  =   33 from 1960.000
          SEE+1 =     1129.26 RBSQ  = 0.8697 DW  =   0.59 DoFree =   30 to   1992.000
          MAPE  =       10.22
        Variable name              Reg-Coef  Mexval t-value   Elas   NorRes     Mean
      0 public education          - - - - - - - - - - - - - - - - - - - - -  13063.64
      1 intercept               -49547.42436   131.5 -11.435  -3.79    8.19      1.00
      2 school-age population     1983.91610   170.3  13.756   5.63    1.55     37.05
      3 stock of pub educ[1]        -0.02279    24.3  -4.045  -0.83    1.00 477923.77
```

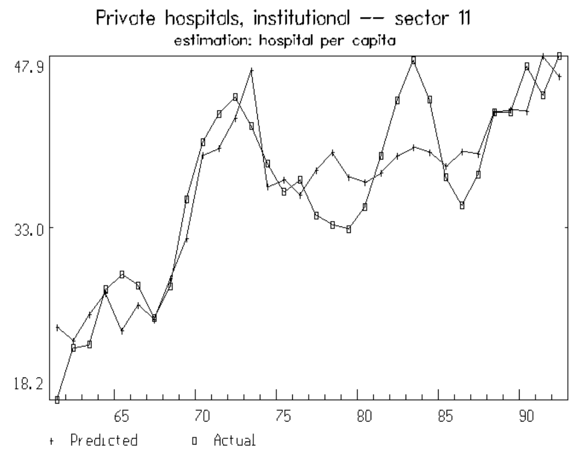



share of the total population over age 55 leads to an increase in private hospital construction. There is substitution, however, between public and private hospitals. An increase in construction of public hospitals of one percent leads to an almost one percent decline in private hospital construction. Finally, the amount of third-party financing for health care also affects construction of private hospitals. An increase in Medicaid of one percent leads to a .6% increase in new hospitals. It should be noted that the equation was estimated in per capita terms, to isolate the effect of increasing demand for hospitals to satisfy a larger population. As seen in the first graph of Figure 15, however, hospital construction has been growing strongly, even when measured in per capita terms.

Figure 16
Estimation Results: Private Hospitals and Institutions

```
                     Private hospitals, institutional -- Sector 11
          SEE   =    3.37 RSQ   = 0.8111 RHO =   0.39 Obser  =   32 from 1961.000
          SEE+1 =    3.18 RBSQ  = 0.7657 DW  =   1.21 DoFree =   25 to   1992.000
          MAPE  =    7.92
```

| | Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|---|
| 0 | private hospitals/pop | - - - | - - - | - - - | - - - | - - - | 36.34 |
| 1 | intercept | -28.16082 | 1.2 | -0.773 | -0.77 | 5.29 | 1.00 |
| 2 | public hospitals/pop | -3.15048 | 18.5 | -3.176 | -0.94 | 5.21 | 10.85 |
| 3 | age 55 and over/pop | 2.44588 | 4.2 | 1.462 | 1.67 | 2.66 | 24.84 |
| 4 | pct chnge in hosp output | 0.71438 | 2.7 | 1.171 | 0.11 | 2.65 | 5.55 |
| 5 | pct chnge in hosp output[1] | 1.00250 | 8.1 | 2.055 | 0.15 | 2.36 | 5.61 |
| 6 | pct chnge in hosp output[2] | 1.17734 | 13.8 | 2.714 | 0.19 | 1.96 | 5.76 |
| 7 | S&L transfers/pop | 176.33827 | 39.9 | 4.893 | 0.59 | 1.00 | 0.12 |





Miscellaneous nonresidential structures includes such not-elsewhere-classified structures as passenger terminals, greenhouses, and animal hospitals. The equation uses two measures of overall nonresidential construction, Stores and Highways, as demand variables. In addition, construction of miscellaneous nonresidential structures depend negatively on lagged interest rates. Finally, the equation also uses population as a trend variable.

Nonresidential farm buildings are explained by a distributed lag on farm production, as well as a distributed lag on relative farm prices. As agricultural prices and agricultural production rise, construction of farm buildings increase. In addition, farm construction responds negatively to interest rates.

Figure 17
Estimation Results: Miscellaneous Nonresidential Structures

Misc. Nonresidential -- Sector 12

```
SEE   =     258.71 RSQ   = 0.8917 RHO =   0.13 Obser  =   25 from 1968.000
SEE+1 =     258.46 RBSQ  = 0.8701 DW  =   1.75 DoFree =   20 to   1992.000
MAPE  =       5.93
```

| | Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|---|
| 0 | misc nonresident | - - - | - - - | - - - | - - - | - - - | 2932.96 |
| 1 | intercept | -6432.77598 | 66.2 | -5.934 | -2.19 | 9.24 | 1.00 |
| 2 | store construction | 0.04775 | 30.7 | 3.760 | 0.42 | 3.95 | 25559.36 |
| 3 | highway construction | 0.04080 | 13.7 | 2.422 | 0.33 | 2.60 | 23976.00 |
| 4 | interest on AAA-bonds[1] | -103.48220 | 13.4 | -2.387 | -0.33 | 2.56 | 9.30 |
| 5 | population | 35.67541 | 60.0 | 5.588 | 2.77 | 1.00 | 227.87 |

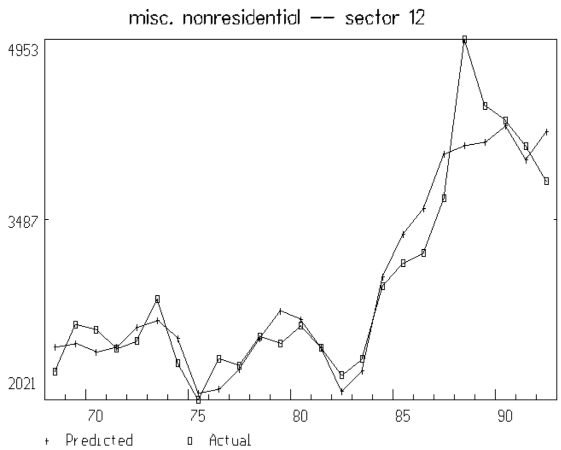



Figure 18
Estimation Results:
Farm Buildings

```
   Farm   Construction   --
Sector 13
          SEE       =
723.92 RSQ   = 0.8765 RHO =
 0.59 Obser  =   32 from 1961.000
          SEE+1 =     611.14 RBSQ  = 0.8404 DW  =   0.83 DoFree =   24 to   1992.000
          MAPE  =      13.39
        Variable name               Reg-Coef  Mexval t-value   Elas   NorRes      Mean
      0 farm                       - - - - - - - - - - - - - - - - - - - - - -  5200.00
      1 intercept               -6972.81691    56.8  -5.914  -1.34    8.09      1.00
      2 change in agric output      0.05699     8.5   2.068   0.03    8.07   3048.35
      3 change in agric output[1]   0.04356     5.0   1.566   0.02    8.06   2868.71
      4 change in agric output[2]   0.05112     6.7   1.818   0.03    8.01   3082.17
      5 interest on AAA bonds     -57.79651     2.1  -1.006  -0.09    7.69      8.36
      6 agric dfl/gnp dfl          62.10855    18.0   3.067   1.12    1.80     93.42
      7 agric dfl/gnp dfl[1]       22.14929     1.1   0.734   0.40    1.21     94.37
      8 agric dfl/gnp dfl[2]       45.18071     9.8   2.221   0.83    1.00     95.33
```

Figure 18 (continued)
Estimation Results: Farm Buildings

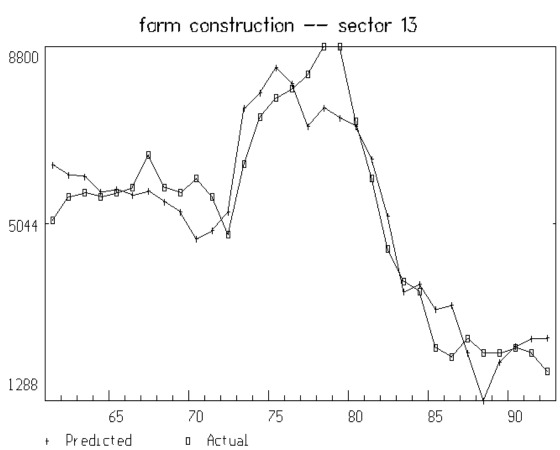
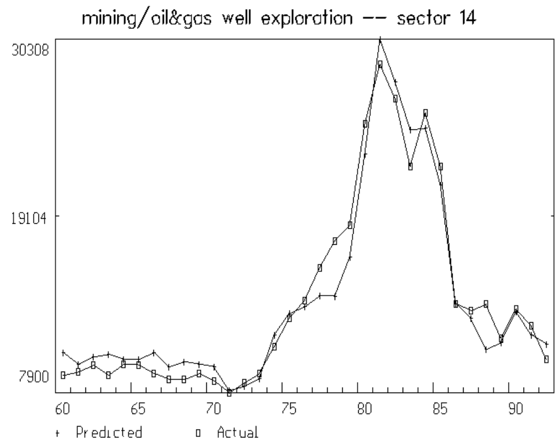



Figure 19
Estimation Results: Mining/Oil & Gas Well Exploration

```
                    Mining/Oil&gas well Exploration -- Sector 14

          SEE   =    1287.21 RSQ   = 0.9540 RHO =   0.49 Obser  =   33 from 1960.000
          SEE+1 =    1137.33 RBSQ  = 0.9434 DW  =   1.02 DoFree =   26 to   1992.000
          MAPE  =       7.39
```

| | Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|---|
| 0 | mining | - - - - - - - | - - - - | - - - - - | - - - | - - - - - | 13681.82 |
| 1 | intercept | 1971.47750 | 15.1 | 2.938 | 0.14 | 21.23 | 1.00 |
| 2 | crude petrol dfl/gnp dfl | 81.90414 | 107.3 | 9.366 | 0.61 | 1.64 | 101.93 |
| 3 | crude petrol dfl/gnp dfl[1] | 33.68754 | 20.9 | 3.510 | 0.25 | 1.27 | 101.55 |
| 4 | crude petrol dfl/gnp dfl[2] | 9.65995 | 2.1 | 1.051 | 0.07 | 1.27 | 101.06 |
| 5 | change in mining output | 175.11571 | 9.3 | 2.278 | 0.01 | 1.10 | 0.94 |
| 6 | change in mining output[1] | 21.03136 | 0.1 | 0.281 | 0.00 | 1.10 | 1.08 |
| 7 | real interest on AAA bonds | -346.94518 | 5.0 | -1.656 | -0.09 | 1.00 | 3.53 |




As with the farm sector, construction of Mining and Oil and gas wells also depends positively on lagged changes in production and prices, and negatively on the interest rate. (The price used is the price of crude petroleum.) The history of this sector includes a boom in construction after the oil-price shocks of the 1970s, as well as a decline from 1982 through 1985.

Railroad construction depends on both demand and substitution variables. A distributed lag on the output of the railroad sector represents increased demand for railroads. Likewise, an increase in the price of oil, representing an increase in the cost of trucking, also leads to an increased demand for railroads. On the other hand, an increase in Highways, the chief substitute for rails, leads to a fall in rail construction. Finally, rail construction is also affected negatively by the real interest rate lagged one year.

The next sector, Telephone and telegraph construction, is heavily affected by other construction activity in the economy. Demand for new telecommunications facilities respond positively, therefore, to changes in residential construction and construction of office buildings. In addition, as the stock of existing facilities wears out, demand for new construction also rises. Finally, new construction will be delayed as real interest rates rise.

Figure 20
Estimation Results: Railroad Construction

Railroad Construction -- Sector 15

```
SEE   =     352.61 RSQ   = 0.6262 RHO =   0.47 Obser  =   33 from 1960.000
SEE+1 =     314.65 RBSQ  = 0.5399 DW  =   1.05 DoFree =   26 to   1992.000
MAPE  =       9.84
```

| | Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|---|
| 0 | railroad construction | - - - - - - - | - - - - | - - - - - | - - - | - - - - - | 2978.79 |
| 1 | intercept | 1703.46310 | 4.7 | 1.584 | 0.57 | 2.67 | 1.00 |
| 2 | highway construction | -0.01223 | 0.5 | -0.518 | -0.10 | 1.70 | 25181.82 |
| 3 | oil price/gnp dfl [2] | 11.53551 | 20.7 | 3.446 | 0.39 | 1.70 | 101.06 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 real interest on AAA[1] | -269.76906 | 25.8 | -3.889 | -0.31 | 1.57 | 3.43 |
| 5 output of railways | 0.04620 | 6.2 | 1.823 | 0.42 | 1.34 | 27132.17 |
| 6 change in railway output | 0.09517 | 6.9 | 1.923 | 0.01 | 1.26 | 360.95 |
| 7 change in railway output[1] | 0.15268 | 12.4 | 2.620 | 0.02 | 1.00 | 355.49 |

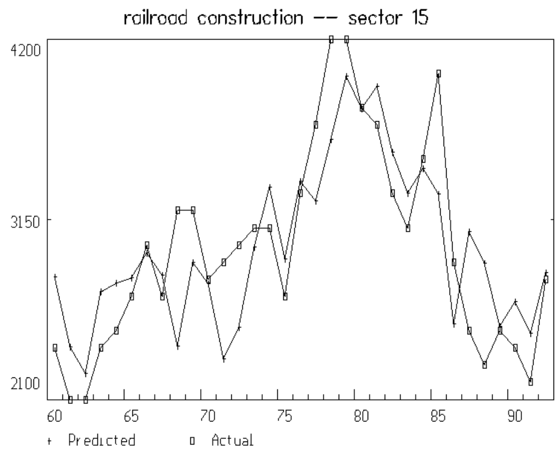



Figure 21

## Estimation Results: Telephone/Telegraph Construction

Telephone, telegraph -- Sector 16

```
SEE   =      355.51 RSQ   = 0.9709 RHO =   0.40 Obser  =   33 from 1960.000
SEE+1 =      327.64 RBSQ  = 0.9655 DW  =   1.21 DoFree =   27 to   1992.000
MAPE  =        4.62
```

| Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|
| 0 telephone | - - - - - - | - - - | - - - - | - - - | - - - - | 6187.88 |
| 1 intercept | -1416.30911 | 23.4 | -3.756 | -0.23 | 34.38 | 1.00 |
| 2 residential struct | 0.01478 | 16.8 | 3.132 | 0.26 | 22.36 | 107287.88 |
| 3 residential struct[1] | 0.00704 | 4.2 | 1.522 | 0.12 | 18.15 | 106315.15 |
| 4 office construct | 0.09741 | 49.4 | 5.765 | 0.29 | 5.53 | 18595.14 |
| 5 wear-out of stock | 0.94027 | 105.3 | 9.317 | 0.70 | 1.64 | 4597.12 |
| 6 real interest rate[1] | -251.95788 | 27.9 | -4.141 | -0.14 | 1.00 | 3.43 |

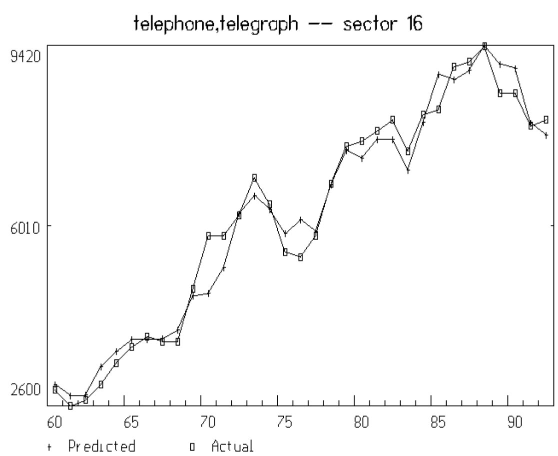



Figure 22

## Estimation Results: Gas and Petroleum Pipelines

Gas, Petroleum pipelines --Sector 18

```
SEE   =      550.83 RSQ   = 0.7788 RHO =   0.32 Obser  =   32 from 1961.000
SEE+1 =      546.76 RBSQ  = 0.7363 DW  =   1.36 DoFree =   26 to   1992.000
MAPE  =        8.22
```

| Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|
| 0 pipelines | - - - - - - | - - - | - - - - | - - - | - - - - | 5000.00 |

| | Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|---|
| 1 | intercept | 4681.67951 | 185.6 | 13.640 | 0.94 | 4.52 | 1.00 |
| 2 | Alaskan oil dummy | 1361.68415 | 31.2 | 4.332 | 0.05 | 2.28 | 0.19 |
| 3 | real interest rate | -111.30312 | 5.4 | -1.696 | -0.08 | 1.58 | 3.55 |
| 4 | chnge in pet ref out[2] | 0.02677 | 3.3 | 1.321 | 0.01 | 1.56 | 2669.11 |
| 5 | chnge in pipeline out[3] | 1.00415 | 4.6 | 1.565 | 0.03 | 1.26 | 157.64 |
| 6 | chnge in pipeline out[4] | 1.41004 | 12.2 | 2.592 | 0.05 | 1.00 | 161.98 |

Figure 22 (continued)
Estimation Results: Gas and Petroleum Pipelines

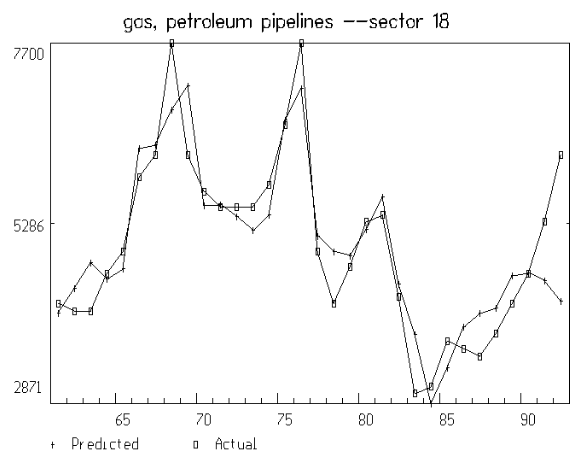


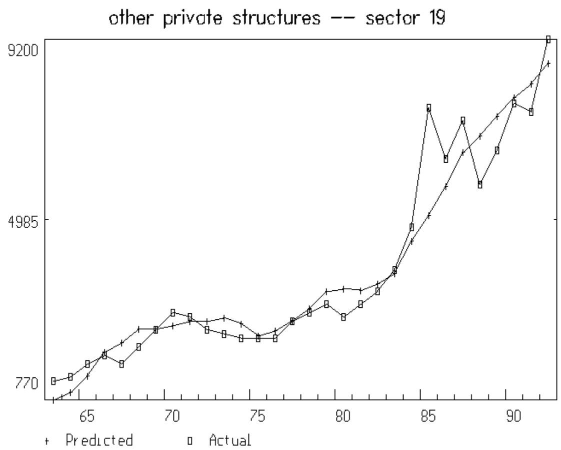

Figure 23
Estimation Results: Other Private Structures

Other Private Structures -- Sector 19

```
SEE   =     634.34 RSQ   = 0.9224 RHO =   0.35 Obser  =   30 from 1963.000
SEE+1 =     597.45 RBSQ  = 0.9166 DW  =   1.29 DoFree =   27 to   1992.000
MAPE  =      12.26
```

| | Variable name | Reg-Coef | Mexval | t-value | Elas | NorRes | Mean |
|---|---|---|---|---|---|---|---|
| 0 | other private structures | - - - | - - - | - - - | - - - | - - - | 3760.00 |
| 1 | intercept | -8531.90625 | 101.7 | -9.103 | -2.27 | 12.88 | 1.00 |
| 2 | highway construction | 0.15060 | 49.8 | 5.794 | 1.01 | 12.87 | 25103.33 |
| 3 | personal consumption[1] | 3.79493 | 258.8 | 17.906 | 2.26 | 1.00 | 2242.79 |

Construction of Gas and petroleum pipelines depends positively on production of the petroleum refining sector, as well as the sector for pipeline services. The sector also responds negatively to changes in the real interest rate. Finally, the equation also uses a dummy variable to represent construction of the Alaskan pipeline project in the mid 1970s.




The final sector is a miscellaneous category called Other private structures, and it includes structures such as private streets, dams, parks, and airfields. Since these miscellaneous items are linked to overall development, the equation uses highway construction and personal consumption expenditures to capture changes in demand for these structures.

Forecasts of Construction, December 1993

The outlook for construction over the next fifteen years depends, in part, on the overall forecast for economic growth. Figures 24 and 25 illustrate Inforum's December 1993 forecast for growth in real Gross Domestic Product and for the interest rate on 30-year mortgages. In general, the forecast shows that 1993 and 1994 are recovery years from the 1990-1992 recession. These growth years are followed by a cyclical downturn as GDP growth slows to about half a percent in 1996. The long-term outlook, from 1997-2010, shows modest GDP growth averaging close to 1.8% per year. Interest rates remain low in 1994, and then begin to rise through 1997. From then on, however, interest rates remain relatively low. For instance, the mortgage rate averages less than 8% through the year 2010.

The construction outlook also is affected by the forecast for demographic variables. Figure 26 illustrates the percent of households in the U.S. where the head of household is between the ages of 25 and 35 years old. Historically, families of this age make up the largest group of first-time home buyers. For the past ten years, this variable has declined steadily, as the baby-boom generation aged. That decline is forecast to continue through 1995. From 1995 to 2002, the share remains relatively constant. In the last eight years of the forecast, the share begins to rise, as the children of baby-boomers enter the home-buying age.

Figure 24
Growth of Gross Domestic Product
percent change in constant $ GDP

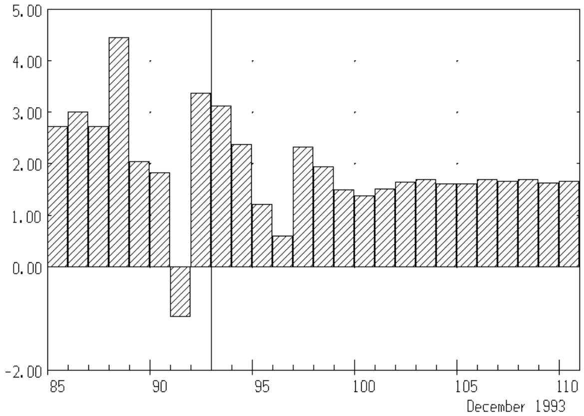
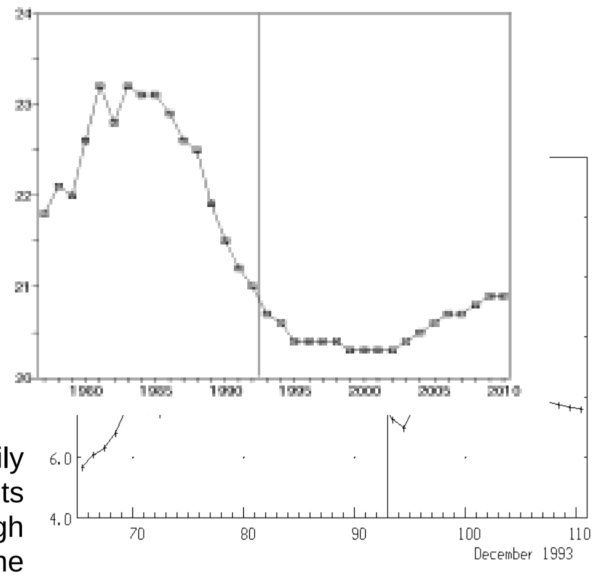



Figure 26
Households of Home-buying Age (%)
head of household age 25-35




The outlook for Single-family and Multi-family units is shown in Figures 27-30. Single-family units continue to recover from the 1990 recession through 1994. As interest rates rise and overall income growth slows in 1995 and 1996, single-family construction falls. (The decline is relatively modest by historical standards.) Over the long-term, single-family units per household remain relatively flat through the year 2000. As interest rates fall slightly, and as the percent of households of home-buying age starts to increase, single-family units per household rise slowly.

The percent of households of home-buying age also affects the outlook for multi-family units. These structures continue to recover from the sharp decline of the last decade over the first six years of the forecast. As the share of elderly households continues to rise slightly (ie. the percent of households of home-buying age falls), the demand for multi-family units increases. Over the long-term, as single-family units per capita rise, the multi-family units per capita remain flat. In general, residential construction grows only modestly well in the forecast; neither single-family nor multi-family units reach their most recent historical peak value, in per capita terms, by the year 2010.

Figure 27
Single-family Units
millions of 1977 $

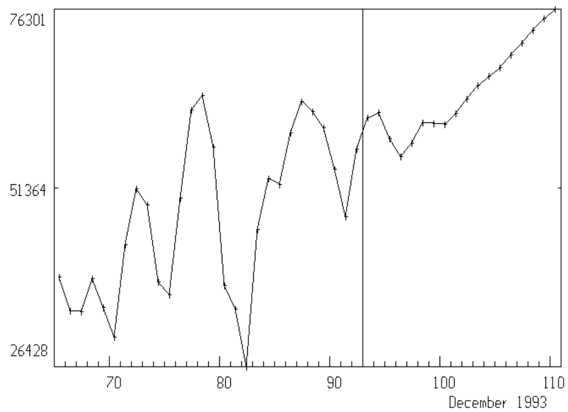
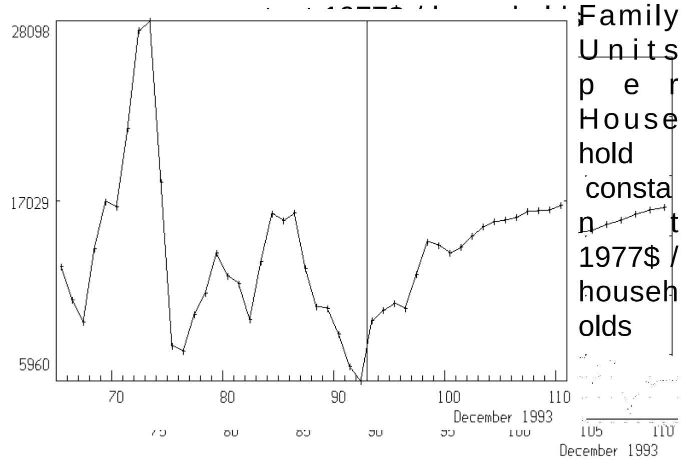



Figure 29
Multi-Family Units
millions of 1977 $

Figure 28
Single-Family Units per Household

Figure 30
Multi-Family Units per Household
constant 1977$ / households




The outlook for nonresidential structures in the Inforum December 1993 forecast shows a modest recovery from the 1990 recession in 1994 and 1995. The recovery stalls in 1996, as interest rates rise and overall demand slows. Over the long-term, nonresidential structures grow steadily, in response to the overall steady growth of the economy and continued low interest rates. Some of the sectors with strongest growth are Industrial structures, Stores, Hospitals, and Telecommunications. Even with the overall growth in nonresidential structures, however, its share of GDP does not recover to its level before the 1990 recession (Figure 32).

Figure 31
Nonresidential Structures
billions of 1977 $

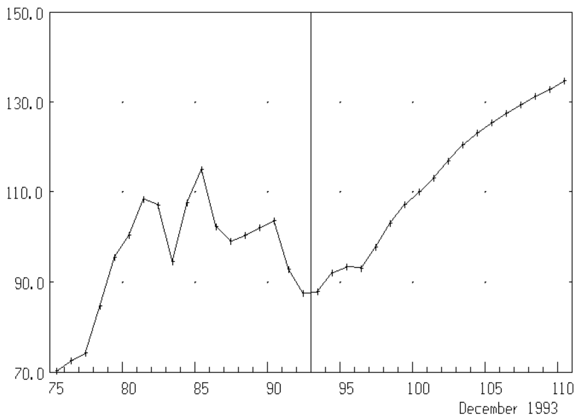
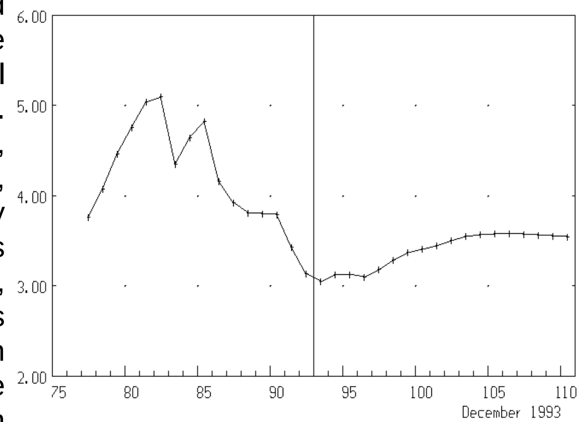



Figure 32
Nonresidential Structures / GDP
percent




## Conclusions

This paper has described equations and forecasts for purchases of structures by type. The equations are included in Inforum's multi-sectoral macroeconomic model of the U.S. economy, LIFT. In general, structures depend on demand variables, such as personal income or industry production, interest rates, and demographic variables. Many types of structures are extremely volatile, such as single-family units, while others are more trended, such as private schools. The LIFT model's aggregate outlook for construction summarizes both the volatile and trended series. In addition, while the overall economic outlook affects construction demand for different types of structures, there also is feedback from structures to the rest of the economy. For instance, an increase in residential construction creates demand for steel and carpeting, while highway construction creates demand for tar and heavy equipment. By specifying different types of structures purchases, LIFT is able to model those different economic affects.

## References

This paper and the estimation work evolved from earlier work done by Charles W. Griffiths, summarized in Construction Equations and Forecasts, March 1993.