Investment in Structures in *IDLIFT*

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Introduction

Private construction expenditures often reflect the health of the American economy. Private construction not only is highly procyclical but also constitutes a large percentage of fluctuations in GDP. While it certainly is an important component of long run growth and forecasting, private construction undoubtedly also is critical to short run forecasting of the business cycle. The *IDLIFT* model of the American economy thus pays considerable attention to private investment in structures by modeling and forecasting 25 categories of construction spending. Following an overview of the sectors, this paper presents the residential and nonresidential equations and empirical results that are used to build the *IDLIFT* model. The model then is used to forecast investment in each sector of private construction from 2001 to 2010. The paper is made complete with a brief summary.

Annual data from 1961 to 2000 reveal four peaks and corresponding troughs in real GDP, which are shown in Table 1. Together with dates of each contraction, the table shows the fall in real GDP (in billions of 1987 dollars); real private nonresidential, private residential, and total private construction; and the change in each construction category as a percentage of the change in GDP. With one exception, both nonresidential and residential construction fell with GDP[1]. Changes in total construction relative to changes in GDP range from 36% to 433%. Changes in construction relative to changes in GDP range from –35% to 68% for nonresidential construction and from 32% to 468% for residential construction. Thus contributions of investment in structures to business cycles far exceed its contribution to levels of GDP. On average, nonresidential and residential construction comprised 4.4% and 4.3% of nominal GDP, respectively; thus private construction comprised an average 8.7% of nominal GDP from 1961 to 2000. Closer examination of the shares, displayed in Figure 1 for total private, nonresidential, and residential construction, reveals residential shares to be more volatile than nonresidential shares. Residential shares exhibit a slight downward trend, although the trend may have reversed in the 1990's. Nonresidential construction shares trended upward from 1961 to the late 1970's, rose dramatically through the early 1980's, and then fell quickly. Shares again have been rising since 1994, but they still are lower than any between 1961 and 1990. While this paper does not present direct analysis of these phenomena, the behavior of these investment shares warrants further investigation.

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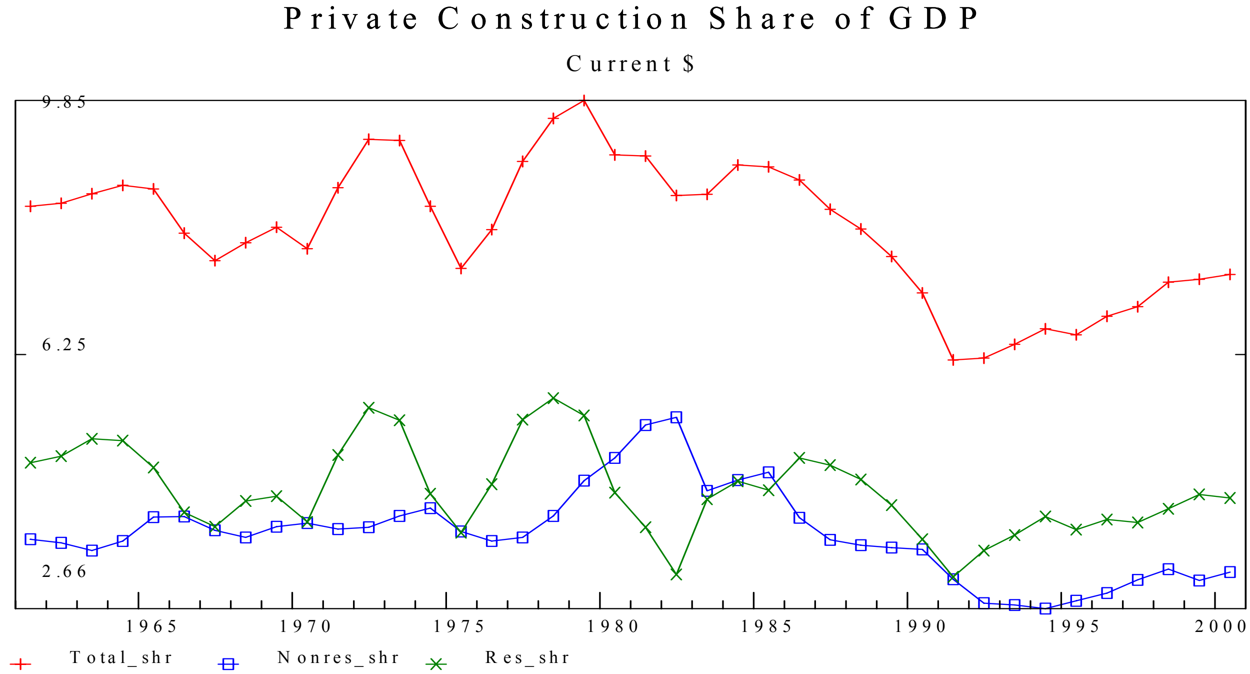
[1] Nonresidential construction growth was slightly positive in 1980, although GDP fell. The economic slowdown may have affected nonresidential structures investment with a lag, for while recovery began in 1983, real investment growth was still far below zero.

Table 1: Investment and Recession

Peak to Trough: real GDP	Fall in Real GDP	Fall in Real Private Nonresidential Construction	ΔNonres. Construction / ΔGDP	Fall in Real Private Residential Construction	ΔRes. Constr. / ΔGDP	Fall in Total Real Private Construction	ΔTotal Constr. / ΔGDP
1973-1975	29.9	16.9	56.4%	63.7	212.8%	80.6	269.2%
1979-1980	8.3	(-)2.9	(-)35.5%	38.7	468.6%	35.8	433.1%
1981-1982	78.3	3.8	4.8%	24.7	31.6%	28.5	36.4%
1990-1991	24.5	19.8	80.6%	25.9	105.7%	45.6	186.3%

Figure 1



Although the correlation is strong between both nonresidential and residential construction and output, volatility of construction growth is far greater than volatility of GDP growth. The standard deviations and cross correlations of GDP growth and construction growth are shown in Table 2. Most notable is while nonresidential construction growth is far more volatile than output growth, residential construction growth realizes still greater volatility. Cross correlations between output and construction are strongly positive (0.6) for both nonresidential and residential construction and are stronger still (0.8) for total private construction. The relationship between residential and nonresidential construction growth is more interesting. Contemporaneous correlation is positive but weak (0.14), but correlation between current nonresidential construction and lagged residential construction is much stronger (0.56). Perhaps nonresidential construction reacts more slowly than residential construction to the same macroeconomic phenomena, or perhaps both react to local events. For example, the construction of new communities of residences stimulates the construction of nearby shopping centers, schools, office buildings, and local business, so nonresidential construction may be related to or follow residential construction.

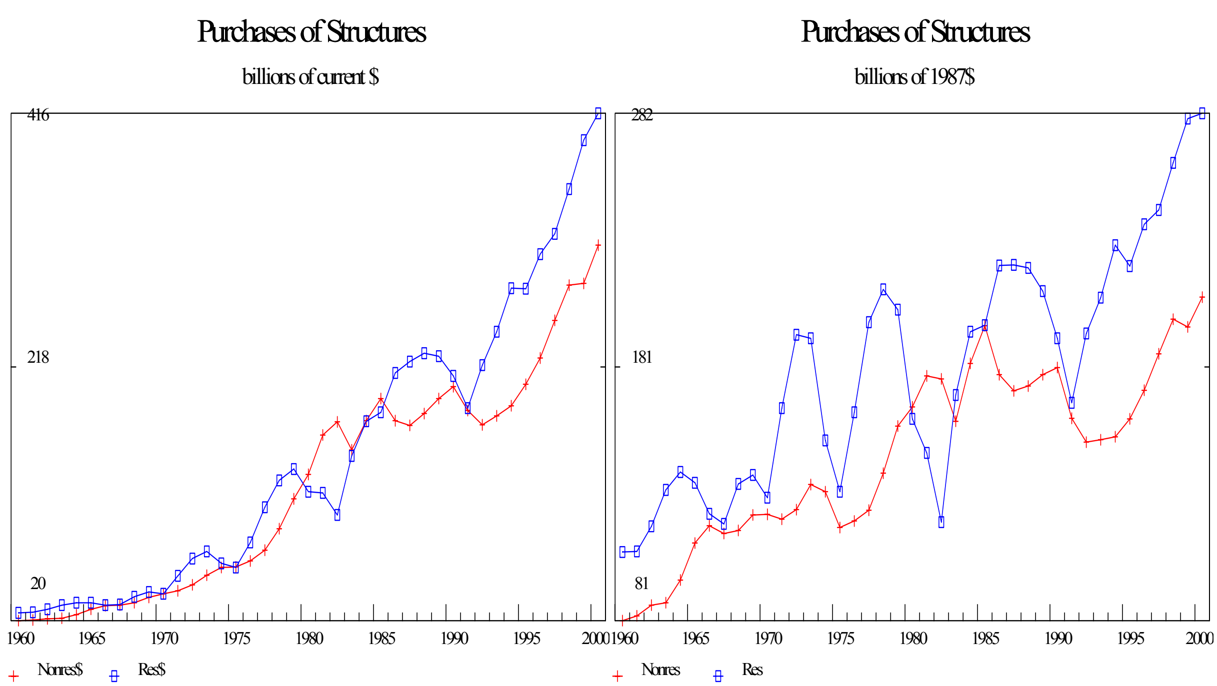
Table 2: Dynamics of Investment and Output Growth

1961-2000	St. Dev.	Cross Correlations				
Real growth rates:		GDP	NR	R	R[1]	Structures
GDP	0.02	1.000	0.629	0.648	0.455	0.799
NR	0.06	0.629	1.000	0.143	0.566	0.537
R	0.13	0.648	0.143	1.000	0.174	0.907
R[1]	0.13	0.455	0.566	0.174	1.000	0.395
Structures	0.07	0.799	0.537	0.907	0.395	1.000

Overview

Figure 2 presents graphs of nominal and real levels of residential and nonresidential construction. Two facts are suggested: residential and nonresidential construction follow similar paths, and residential construction is far more volatile than nonresidential construction. Given that the similarity of paths holds for both real and nominal investment, the relationship most likely is not a result of improper deflation.

Figure 2



Similarities in the behavior of residential and nonresidential construction are not surprising since economic theory suggests both respond to similar economic events. Table 3 summarizes the construction equations in *IDLIFT*. This table suggests that nearly all construction sectors depend on some measure of output, income, or expenditures as an indicator of demand. For example, Sector 1 (Single Family Units) depends on levels of and changes in disposable income, and Sector 13 (Farm Construction) depends on the level and changes in agricultural output. Many sectors also depend on a measure of interest rates. Sector 4 (Additions and Alterations) depends on real mortgage rates, and Sector 6 (Industrial Structures) depends on the real corporate bond rate. Given the high correlation among the measures of demand and among interest rates, it is not surprising that residential and nonresidential construction also exhibit similar behavior. Most residential sectors also depend on the percentage of households of home-buying age (25-34). Some nonresidential structures depend on the stock of structures in the respective sector. The stock of structures may be important to many sectors, but the nature of the relationships is not clear, the parameters are difficult to estimate with limited data, and such measures of stock essentially become autoregressive terms in the model; such terms can lead to wildly inaccurate forecasts in the long run. Inclusion of stocks seemed to improve estimation for only two sectors: Hotels and Offices. Of course, these equations are *ad hoc*; tests of a theoretical model that includes stocks might yield greater success. Such a model also might account for depreciation of stocks of structures. These equations abstract from such concerns and instead predict gross investment.

Table 3: Summary of Investment Equations

Sector Number and Title: Residential Structures	**Income or Spending**	**Interest Rates**	**% of Hhlds of Home-Buying Age**	**Other**
1 Single-family homes	+	-	+	Interest rate dummy
2 Multi-family homes	+		+	Tax dummy
3 Mobile Homes	+	-		Tax dummy, Unemployment rate
4 Additions / Alterations	+		+	Sector 1 / (Sector 1+ Sector 2)
25 Brokers' commissions	+	-	+	
Sector Number and Title: Nonresidential Structures	**Industry Output or Income**	**Interest Rate**	**Stock of Structures**	**Other**
5 Hotels, Motels, Dorms	+	-		Income minus average income, interest*stock
6 Industrial Structures	+			Profits
7 Offices	+			Tax dummy, # Employees / Stock of structures in services
8 Stores, Restaurants, Garages	+			Total residential construction
9 Religious Structures	+			Unemployment rate
10 Private Education				Personal consumption, School aged share of population, Unemployment rate
11 Private Hospitals		-		Consumption expenditures for health care, Insurance spending / Total, Research, Avg. stay
12 Misc. Nonresidential Structures	+	-		Construction in Sector 8
13 Farm Construction	+	-		Agricultural prices
14 Mining & Oil Wells	+			Relative oil prices
15 Railroads	+	-		Public highways, Relative oil prices
16 Telephone/Telegraph	+	-		Total residential construction, Construction in Sector 7
17 Electric Utilities	+	-		%Δ in number of households, Relative price of oil, interest rates * stocks
18 Petroleum Pipelines	+	-		Relative oil prices
19 Other Private Structures				Personal consumption, government construction, highways and streets

Less apparent are the reasons for much higher volatility in residential than in nonresidential construction. The wide swings in residential construction perhaps can be explained by monetary policy and the availability of credit. Regulation Q, a federal policy enacted during the Great Depression and phased out in the early 1980's, may have caused large changes in the availability of credit. It introduced a trigger point for interest rates which, when reached, induced investors to reduce bank deposits. Upon such flights, banks had less money with which to fund mortgages and thus the housing market suffered. These equations do not account for Regulation Q or other such policies directly. If policies are coordinated or at least correlated, other variables in the model that directly or indirectly reflect policies may proxy for Regulation Q. Additional experimentation may reveal a direct measure of policy to be more helpful, and again, a theoretical model may prove more useful than ad hoc models. So far, however, direct measures of policy have not yielded consistent improvements. Of course, Regulation Q ended in the early 1980’s; its incorporation in this model is meant to improve fit of historical data rather than to improve forecasts directly.

About half of the equations employ soft constraints. Soft constraints are a way of combining *a priori* theoretical information or opinions about the values of model parameters with what the data suggests the value of those parameters should be. The constraint to a specified degree induces the model to conform to priors based on economic theory. “Correct” signs and magnitudes of the coefficients often are essential for reasonable forecasting. The commands available in the G regression program for applying soft constraints are the “con” command, which applies a constraint directly to a single parameter or to a linear function of parameters, and the “sma” command, which "softly" requires the coefficients of a distributed lag to lie on a polynomial of a given order. These command impose "softly" the given constraint on the regression. The trade-off parameter determines how "soft" will be the constraint. Soft constraints also are know as "Theil's mixed estimation" or as "stochastic constraints," and also are a type of Bayesian regression analysis. Most soft constraints used here induce demand parameters to be positive. The presence of constraints is indicated in the text and by a “con” or an “sma” command printed with the regression output. Although they are used conservatively, their presence should be remembered when interpreting parameter signs, magnitudes, and elasticities and when evaluating mexvals and normalized residuals.

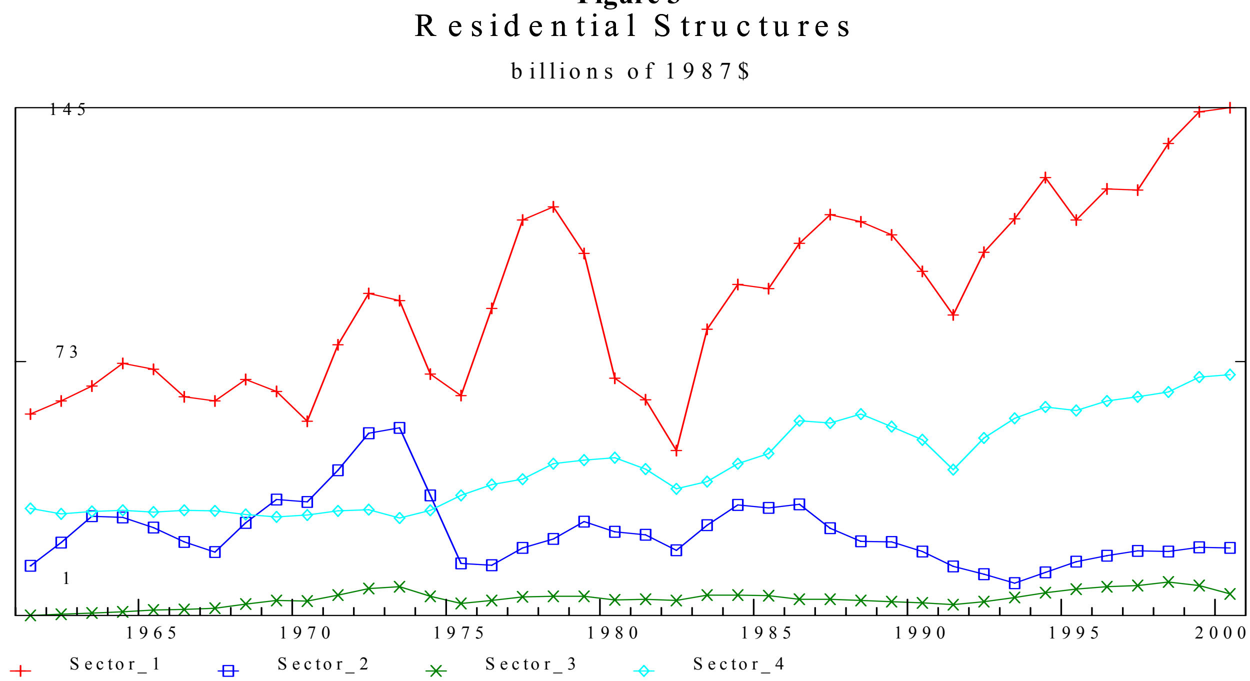
Mexval and NorRes are examples of the "factual" statistics described in "Regression with Just the Facts" (Almon 1996). Such statistics reveal properties of regression parameters without relying on questionable "metaphysical" assumptions about their distributions or about population characteristics. The mexval, or marginal explanatory value, is the percentage increase in SEE if the corresponding variable is omitted from the regression. It is a factual alternative to the *t* statistic. NorRes, or normalized residuals, are the ratio of the sum of squared residuals after the introduction of this variable to the sum of squared residuals after all variables have been introduced. It is a factual alternative to F statistics. Other factual statistics presented in regression output are beta, elasticity, and mean absolute percentage error (MAPE). "Beta" is what the regression coefficient would be if both the independent and dependent variables were scaled so that they had unitary standard deviations. "Elas" is the elasticity of the dependant variable with respect to the corresponding independent variable, evaluated at the means of both. Other statistics presented are:

- RSQ Coefficient of multiple determination.
- RBSQ Coefficient of multiple determination adjusted for degrees of freedom.
- RHO Autocorrelation coefficient of the residuals.
- SEE Standard error of estimate, or the square root of the average of the squared residuals of the equation.
- SEE+1 The SEE for forecasts one period ahead using rho adjustment.
- DW Durbin-Watson statistic; contains same information as does RHO.

Residential Construction

Figure 3 plots components of residential construction and thus yields additional information regarding trends and volatility. Sector 1 (Single family units) exhibits the greatest fluctuations and also is the largest of residential sectors. Given the relative size and stability of the other sectors, Sector 1 thus primarily is responsible for high volatility in total residential construction. Sectors 1, 3 (Mobile homes), and 4 (Additions and alterations) follow similar trends and exhibit similar dynamics. Sector 2 (Multi-family units) exhibits no clear trend, and while its behavior may be procyclical, its is not so apparent as with the other sectors. Each sector grew with the last expansion, yet real investment in multi-family units roughly is the same in 2000 as in 1961. Such phenomena might be expected in per capita data but is surprising when observed in levels of investment. The fact is even more striking when compared to real investment in mobile homes, which grew more than 800% from 1959 to 2000, at an average annual rate of 5.2%.

Figure 3



To capture behavioral patterns rather than the effects of changes in population, all residential sectors are estimated in terms of investment per household. The results of such regression models are graphed in levels per household and in aggregate levels.

Sector 1. Single Unit Residential Structures

Figure 4 presents the first such graphs together with regression results for single-family units. Purchases of single family homes depends positively on levels and current and lagged changes in disposable income. Note, however, the presence of a soft constraint on the parameter for income. The constraint value, .015, is greater than the coefficient, .002; hence OLS would have chosen a smaller, possibly negative, value. The constraint induces the model to conform with priors based on economic theory; here, investment is believed to respond positively to changes in disposable income. Sector 1 also depends negatively on real mortgage rates, positively on the percentage of the population of home-buying age (ages 25 to 34), and positively on a variable related to the mortgage rate. This final term is equal to the mortgage rate from 1976 to 1982 and is equal to zero in all other periods. Thus, the relationship between mortgage rates and Sector 1 investment is given by parameter 5 (-0.108) for periods 1969-1975 and 1983-2000, and is given by the sum of parameters 5 and 7 (-0.108 + 0.024 = (-0.084)) for the period 1976-1982. Without question, the fit improves with the inclusion of this term, as the mexval is quite high. Surely variables that are more satisfying theoretically, for example an indicator of Regulation Q effects, might help even more and would be easier to justify. Nevertheless, this term may be a proxy for dramatic shifts in monetary policy in the late 1970's and early 1980's. A word of caution is in order regarding interpretation of the mexval and other such statistics in the presence of soft constraints. The marginal explanatory value, or mexval, is the percentage by which the SEE would increase if the corresponding variable were dropped from the equation. Unfortunately, mexvals lose much of their usefulness in the presence of constraints, which tend to distort the mexvals. In this case, fortunately, the high mexval is supported by other measures in its declaration of the importance of the dummy variable.

Figure 4

```
                        ti 1. Single Unit Residential Structures

f outman = @csum(out,9-58)/1000.              # Output - manufacturing
f outbus = @csum(out,64,65,72,73,77-80)/1000. # Output - business
f outtrade = @csum(out,69-71)/1000.           # Output - trade
f outmin = @csum(out,2-6)/1000.               # Output - mining
f fpr = (pdm1/pgdp)*100.                      # Farm prices
f rpoil = (pdm5/pgdp)*100.                    # Relative price: oil
f empbus = @csum(emp,64,65,72,73,77-80)       # Employment - business
f di87h = (di87/hhld)*1000.                   # Disposable income per hhld.
fex gdpinfl = (pgdp-pgdp[1])/pgdp[1] * 100.   # Inflation
f rcbr = raaa - gdpinfl                       # Real corporate bond rate
f rcmorr = rcmor - gdpinfl                    # Real mortgage rate
f intDummy= cst1Dummy*rcmor                   # Dummy for Sectors 1, 2

con 10 .015 = a2
r cst1h = di87h,ddi87h,ddi87h[1],rcmor,hhead,intDummy
:                      1. Single Unit Residential Structures
  SEE    =         0.09 RSQ   = 0.8368 RHO =    0.28 Obser  =   32 from 1969.000
  SEE+1  =         0.08 RBSQ  = 0.7976 DW  =    1.44 DoFree =   25 to   2000.000
  MAPE   =         6.62
    Variable name            Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 cst1h                  - - - - - - - - - - - - - - - - -      1.15 - - -
  1 intercept                0.42107     2.9   0.37     5.27      1.00
  2 real disp. inc./hhld     0.00206     0.5   0.07     4.48     37.85  0.045
  3 Δd.i./hhld               0.14378    28.5   0.07     3.69      0.55  0.401
  4 Δd.i./hhld [1]           0.09516    13.0   0.04     3.38      0.52  0.258
  5 mortgage rate           -0.10779    65.5  -0.88     2.45      9.40 -1.052
  6 %hhld heads ages 25-35   7.08560    21.4   1.29     1.82      0.21  0.521
  7 mortgage rate * Dummy    0.02347    35.0   0.04     1.00      2.05  0.474
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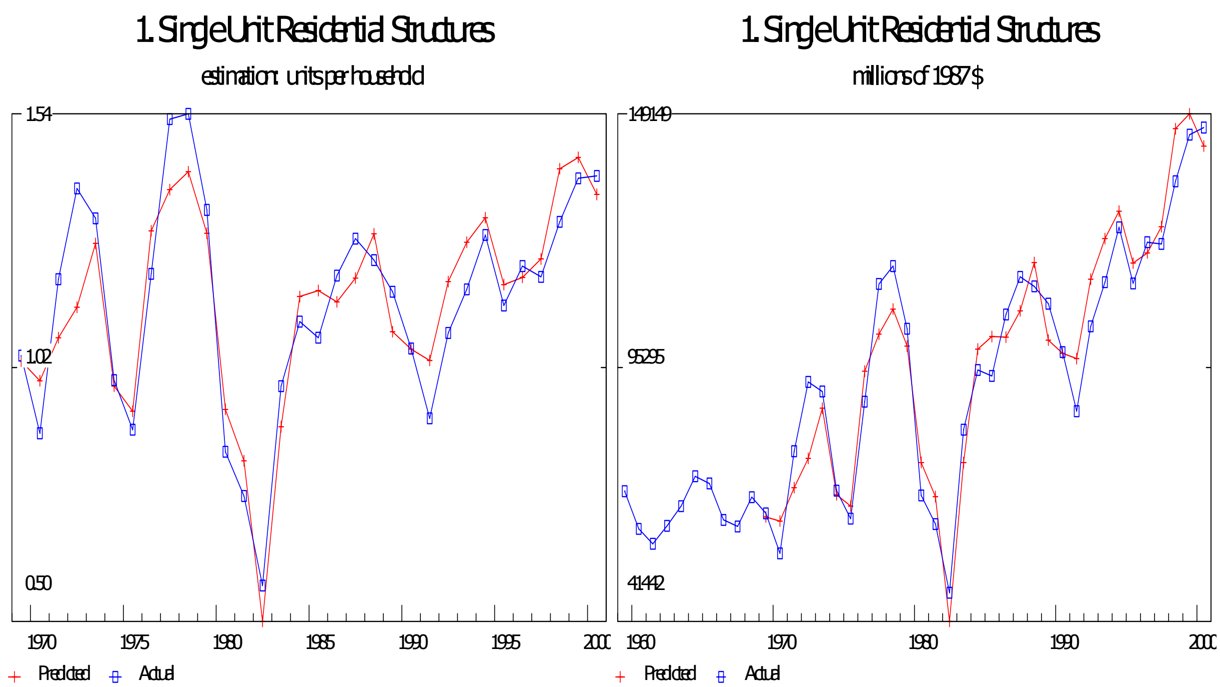

Sector 2. Multi-Unit Residential Structures

Figure 3 reveals real investment in multi-family units to be the third largest among residential sectors, after single-family units and additions, except for a peculiar spike in the early 1970's. Investment is explained by disposable income and its changes. Here income is not measured in terms of levels but instead as a four-year moving average. The moving average starts with the current year and ends with a lag of three years. These first and last terms receive equal weight (0.16), while the first and second lags receive larger weights (0.34). All such terms in this paper are indicated by an 'a' appended to the variable name. This methodology may be viewed as imposing a distributed lag. Given that primarily consumers purchase residential structures, it may be argued that such smoothed income reflects permanent income. Note again the presence of a soft constraint on income that in this case increases coefficient. Sector 2 also depends positively on the fraction of the population that is of home-buying age, and positively on a dummy variable. This dummy variable is equal to 1 in the years 1971-1973, falls to .5 in 1974, and is zero thereafter. This variable was introduced by Monaco (Inforum 1994) to account for tax incentives for investment in apartment buildings. This accounts largely for the spike noted above; without inclusion of this dummy variable, the model suffers greatly. Models which move the starting year to 1975, thus eliminating the troublesome early 1970's, fail to improve upon the model with the dummy variable.

Figure 5

ti 2. Multi Unit Residential Structures

```
# Moving average per-household disposable income, 1987$
  f di87ha = .16*di87h+.34*di87h[1]+.34*di87h[2]+.16*di87h[3]

con 5 .04 = a2
con .0005 1 = a5
r cst2h = di87h,ddi87ha,cst3TaxDum, hhead# ,rcmorr#,intDummy#,
:                      2. Multi Unit Residential Structures
  SEE   =        0.07 RSQ   = 0.8353 RHO =   0.85 Obser  =   29 from 1972.000
  SEE+1 =        0.03 RBSQ  = 0.8079 DW  =   0.29 DoFree =   24 to   2000.000
  MAPE  =      26.40
    Variable name              Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 cst2h                    - - - - - - - - - - - - - - - - -      0.28 - - -
  1 intercept                 -0.44427     3.8  -1.57     3.19      1.00
  2 real disp. inc./hhld       0.00560     1.8   0.76     3.03     38.49  0.155
  3 ΔMoving avg: d.i./hhld     0.00290     0.0   0.01     2.88      0.52  0.006
  4 tax dummy                  0.62497    69.4   0.19     1.25      0.09  1.019
  5 %hhld heads ages 25-35     2.15187    11.9   1.61     1.00      0.21  0.189
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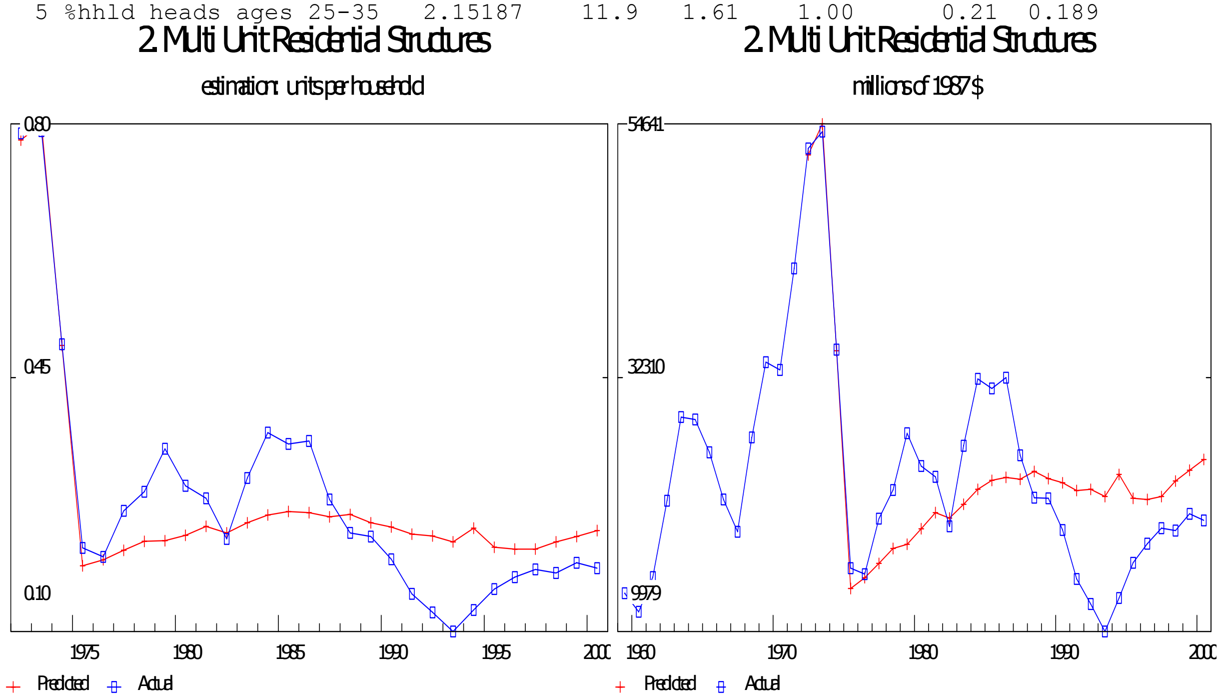

Sector 3. Mobile Homes

We see in Figure 3 that mobile home investment is the least among residential construction sectors. Although the sector is small, its growth in has been strong in the past 40 years; investment from 1959 to 2000 increased by about 1900% in nominal terms and by about 800% in real terms. Figure 6 displays great volatility which was not apparent in Figure 3 because of scaling. Volatility is high also in per household investment, and there is no obvious trend; households invest about the same amount today as they did 25 years ago. In this equation, per household investment depends on average and changes in average personal consumption expenditures. The coefficient on expenditures is positive, but it is subject to a constraint. Real average mortgage rates receive a negative coefficient, as does the change in unemployment rates, and the tax dummy introduced for Sector 2 has a positive coefficient. Justification for including the tax dummy is weak, since the tax breaks were available only for investment in apartments. Perhaps Sector 3 was reacting to other phenomena, or perhaps there is some complementary or causal relationship between Sectors 2 and 3. Regardless of these possibilities, the quality of the regression results depends greatly on this dummy variable, as is suggested by a mexval higher than any other.

Figure 6

ti 3. Mobile Home Construction

```
con 100 .001 = a2
r cst3h = pcexha,dpcexha,rcmorra,duunemp, cst3TaxDum
:                           3. Mobile Home Construction
con 100 .001 = a2
r cst3h = pcexha,dpcexha,rcmorra,duunemp, cst3TaxDum
:                           3. Mobile Home Construction
  SEE    =        0.01 RSQ   = 0.7100 RHO =   0.65 Obser  =   30 from 1971.000
  SEE+1  =        0.01 RBSQ  = 0.6495 DW  =   0.70 DoFree =   24 to   2000.000
  MAPE   =       14.51
    Variable name            Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
  0 cst3h                  - - - - - - - - - - - - - - - - -     0.07 - - -
  1 intercept                0.04840    48.5   0.65    4.24      1.00
  2 avg pers cons exp/hhld   0.00097    34.4   0.43    3.79     33.42  0.205
  3 Δpcexha                  0.00299     0.4   0.02    3.79      0.53  0.065
  4 avg mortgage rate       -0.00294    11.3  -0.19    3.06      4.72 -0.318
  5 Δunemp rate             -0.57521    14.9   0.00    2.65     -0.00 -0.350
  6 tax dummy                0.05018    62.7   0.08    1.00      0.12  0.742
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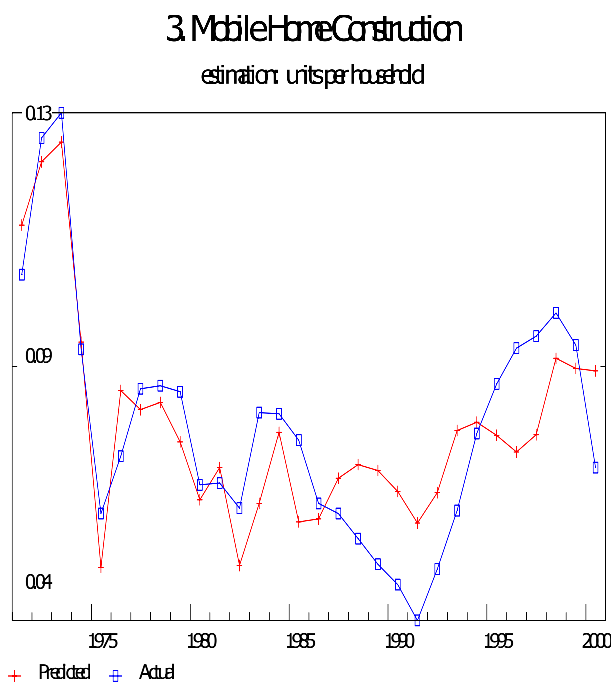

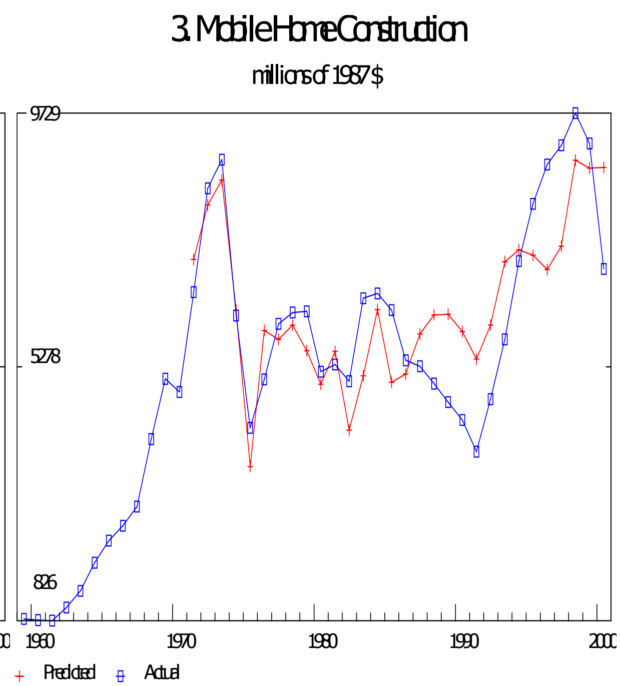

Sector 4. Additions and Alterations

Sector 4, Additions and alterations, typically is second only to single-family units among residential construction sectors. Figure 3 reveals its growth to be strong since 1960 although Figure 7 reveals great volatility. It seems reasonable to expect Sector 4 to exhibit countercyclical behavior as a lower-cost substitute in periods of hardship. Evidence of such behavior is swamped in aggregate data; investment clearly is procyclical. This conclusion is not supported directly by the coefficient sign in the following regression, since the sign is imposed by a constraint. Negative coefficients on income instead are ruled out by resulting implausible forecasts.

In the regression results for this sector, the soft constraint has had a mysterious effect on the mexvals and normalized residuals. These statistics suggest a very poor fit, but inspection reveals a reasonable fit and forecast. This apparent failure of the statistics warrants further investigation.

The estimated coefficients are positive for average GDP and its changes. The sign is positive on the ratio of Sector 1 to the sum of Sectors 1 and 2, and the coefficient on the percentage of the population of home-buying age also is positive.

Figure 7

```
                         ti 4. Additions and Alterations

f singsh = cst1$/(cst1$+cst2$)    # Ratio: Sector 1/(sum of Sectors 1 & 2)
r cst4h = gdpha,dgdpha,singsh,hhead #,rcmorr
:                          4. Additions and Alterations
  SEE   =       0.03 RSQ   = 0.7867 RHO =   0.42 Obser  =   30 from 1971.000
  SEE+1 =       0.03 RBSQ  = 0.7525 DW  =   1.16 DoFree =   25 to   2000.000
  MAPE  =       4.90
    Variable name           Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
  0 cst4h                 - - - - - - - - - - - - - - - - -      0.55 - - -
  1 intercept               0.02728     0.0   0.05    4.69      1.00
  2 average gdp/hhld        0.27973     0.0   0.03    2.15      0.05  0.021
  3 Δaverage gdp/hhld      63.34716    31.0   0.08    1.64      0.00  0.621
  4 Sec1/(Sec1+Sec2)        0.40308    17.6   0.59    1.06      0.80  0.453
  5 head of household       0.68042     2.8   0.26    1.00      0.21  0.138
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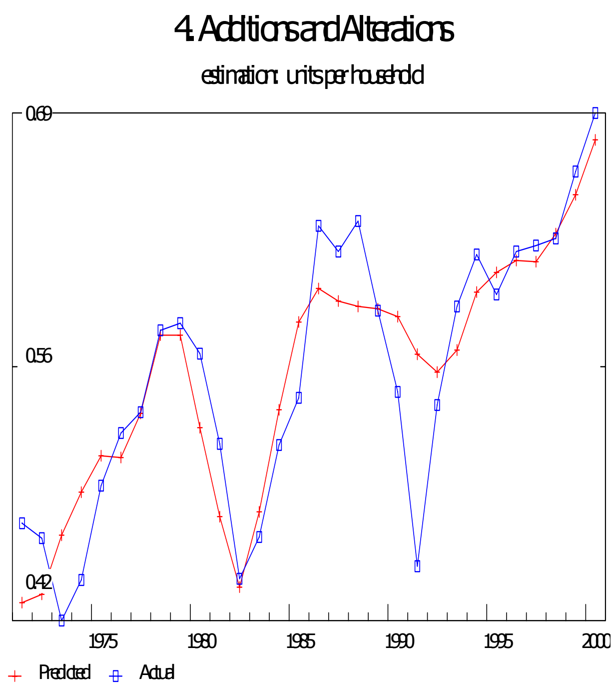
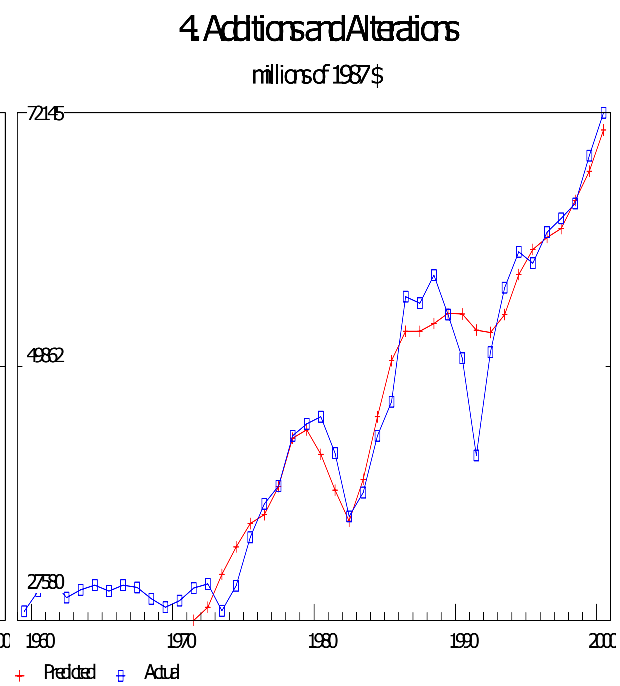




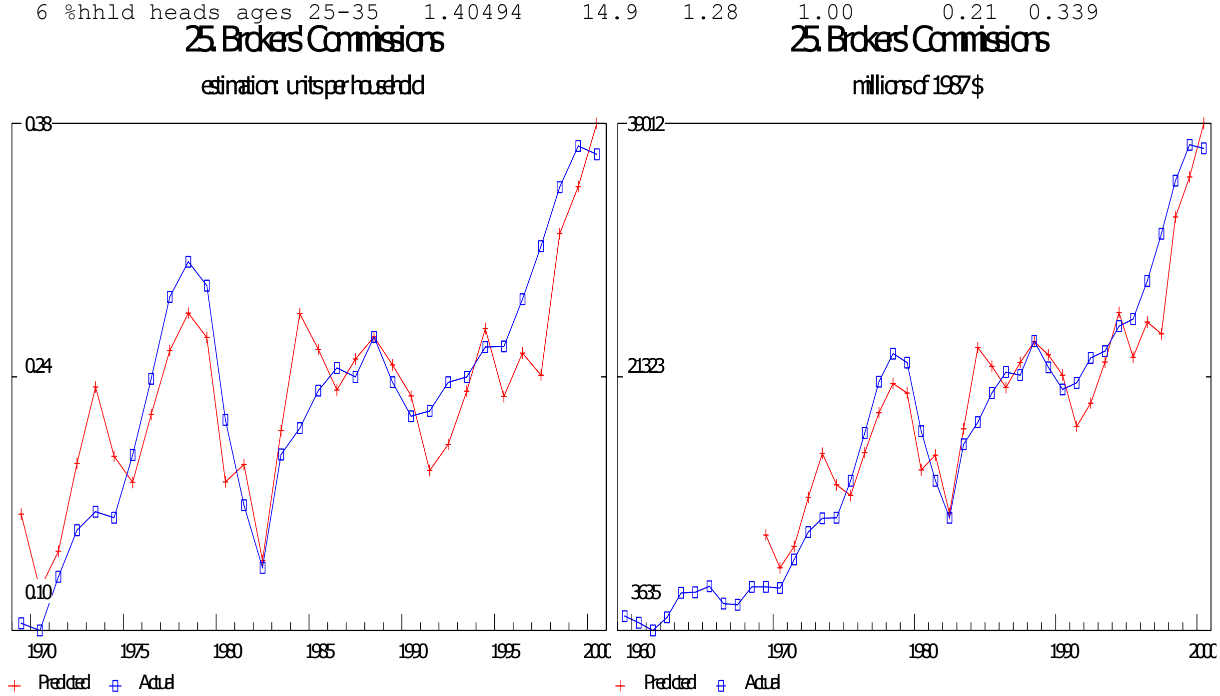
Sector 25. Brokers' Commissions

Brokers' commissions are not graphed in Figure 3. Its mean is similar to that of Sector 2 and it has an upward-sloping trend. In the regression results, the constrained coefficient on GDP is positive, as are coefficients on current and lagged changes in GDP. The mortgage rate enters with a negative coefficient, and the coefficient is also positive on the fraction of the population of home-buying age. Again we see apparent evidence of problems in the statistics caused by the constraint: the mexval for GDP is over 10,000. The coefficient was very responsive to the constraint, as only one artificial observation was required to obtain approximate equality of the coefficient and constraint. In this case, the constraint does more than induce a positive value. In many such equations, the forecast value depends greatly on predictions of GDP or a similar measure of demand. Thus the coefficient on GDP plays a large and perhaps dominant role in determining the trend of investment, even if small changes in the coefficient have little effect on fit of the historical data. In such cases where investment forecasts may otherwise yield implausible trends, a soft constraint on the GDP parameter can be used instead of a fix in the model. This technique was used here, where a coefficient of 3.5 was chosen so that the forecast approximates the Spring 2001 forecast. Fortunately, such manipulation did little harm to the fit of the model over historical data.

Figure 8

```
                        ti 25. Brokers' Commissions and Used Structures

con 1 3.5=a2
r cst25h=gdph,dgdph,dgdph[1],rcmorr,hhead
:                           25. Brokers' Commissions
  SEE   =       0.03 RSQ   = 0.7324 RHO =   0.65 Obser  =   32 from 1969.000
  SEE+1 =       0.03 RBSQ  = 0.6809 DW  =   0.69 DoFree =   26 to   2000.000
  MAPE  =      13.78
    Variable name           Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 cst25h                - - - - - - - - - - - - - - - - -      0.23 - - -
  1 intercept               -0.24708    11.5  -1.07 9999.99      1.00
  2 gdp per household        3.50009 10172.1   0.81    2.12      0.05   0.347
  3 Δ gdp/household         25.25123    23.9   0.08    1.45      0.00   0.439
  4 Δ gdp/household [1]     16.27192     9.3   0.05    1.35      0.00   0.261
  5 real mortgage rate      -0.00691     8.3  -0.14    1.32      4.73  -0.252
  6 %hhld heads ages 25-35   1.40494    14.9   1.28    1.00      0.21   0.339
```

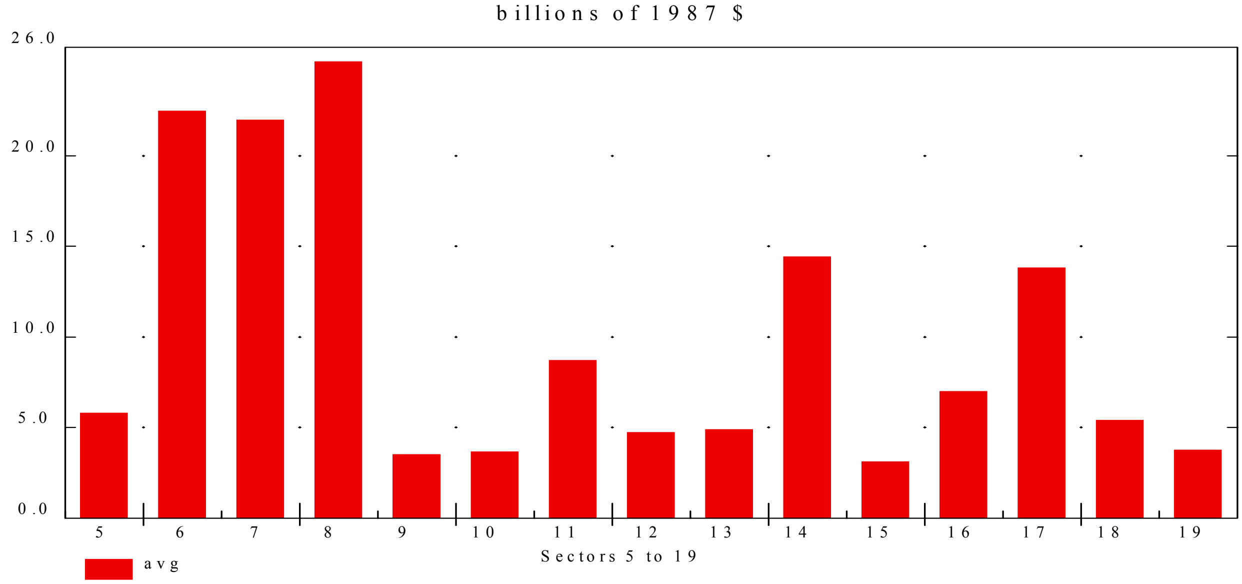


Nonresidential Construction

The small number of sectors categorized as residential structures permits them to be graphed together in Figure 3. The nonresidential category contains many more sectors, which renders a similar graph unreadable. Thus, descriptive statistics are plotted in the following three figures. These figures permit only rough comparisons of sectors; further information can be gleaned from later time plots.

Figure 9 presents levels of the nonresidential sectors averaged over 1959 to 2000. Three sectors, Industrial structures; Offices; and Stores, restaurants, and garages, average over $20 billion in 1987 dollars. Two others, Mining exploration shafts and wells and Electric light and power, average between $10 billion and $20 billion. Investment in other sectors averages less than $10 billion. While total nonresidential investment is similar to total residential investment, as seen in Figure 2, average investment in single family units ($92.2 billion) dwarfs Stores, restaurants, and garages, the largest nonresidential sector.

Figure 9
Average Real Nonresidential Construction by Sector
billions of 1987 $



- Sector 5 Hotels, Motels, and Dormitories
- Sector 6 Industrial structures
- Sector 7 Offices
- Sector 8 Stores, Restaurants, and Garages
- Sector 9 Religious structures
- Sector 10 Educational structures
- Sector 11 Hospitals and Institutional structures
- Sector 12 Miscellaneous Nonresidential buildings
- Sector 13 Farm buildings
- Sector 14 Mining exploration shafts and wells
- Sector 15 Railroads
- Sector 16 Telephone and Telegraph
- Sector 17 Electric Light and Power
- Sector 18 Gas and Petroleum Pipes
- Sector 19 Other structures

The arithmetic means presented above tell nothing of the time paths followed by each sector. Figure 10 thus presents average growth rates, calculated with 1959 as the beginning period and 2000 as the ending period. Clearly, such calculations may be highly sensitive to the choice of these beginning and ending periods, particularly if the sector is susceptible to wide fluctuations of investment. For this reason, the individual time series graphs should be examined for more details; these are presented later. Nevertheless, the average growth rates shown in Figure 10 allow crude comparisons. About half of the sectors grew at rates similar to that of real GDP (3.46%). Two sectors, Religious structures and Electric light and power, averaged between 0% and 1% growth. Farm buildings fell by over one percent per year, while three sectors grew by over 4% per year. From greatest to least, these sectors are Other structures, Offices, and Telephone and Telegraph. Investment growth in Hospitals and institutions also was significant at slightly under 4% per year.

Figure 10

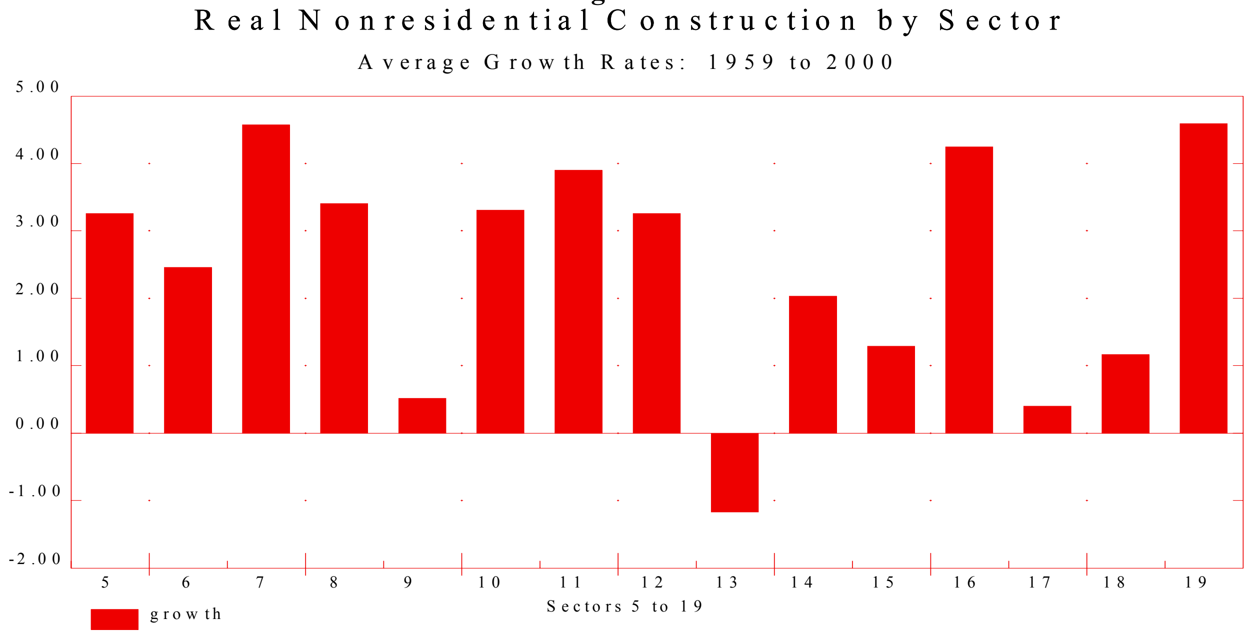
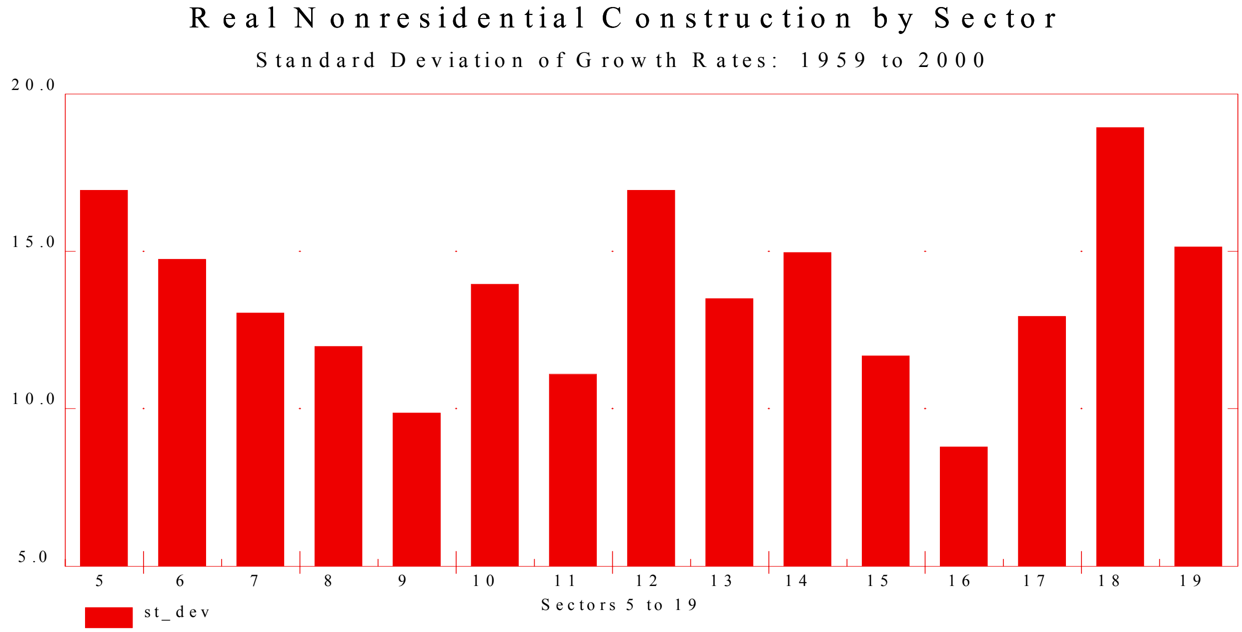


Figure 9 provides average magnitudes of investment and Figure 10 provides average growth rates. The final component of this initial portrayal is a measure of volatility. Figure 11 presents the standard deviation of growth rates, calculated from 1959 to 2000. When compared to the standard deviation of real GDP (3.79), all sectors appear quite volatile. Sector 16, Telephone and telegraph, experienced the least volatility, and investment in Sector 18, Gas and petroleum pipes, was most volatile. Investment in Hotels, motels, and dormitories and in Miscellaneous nonresidential buildings also were highly volatile. While investment growth for Religious structures was modest, Figure 11 shows that growth to be among the most stable of nonresidential sectors.

Figure 11



As the link between population and investment is less clear with nonresidential structures than with residential structures, many equations are estimated in levels. In some equations, it proved helpful to estimate in terms of investment per capita or per household, but usual this was determined by experimentation rather than by theory alone.

Sector 5. Hotels, Motels, and Dormitories

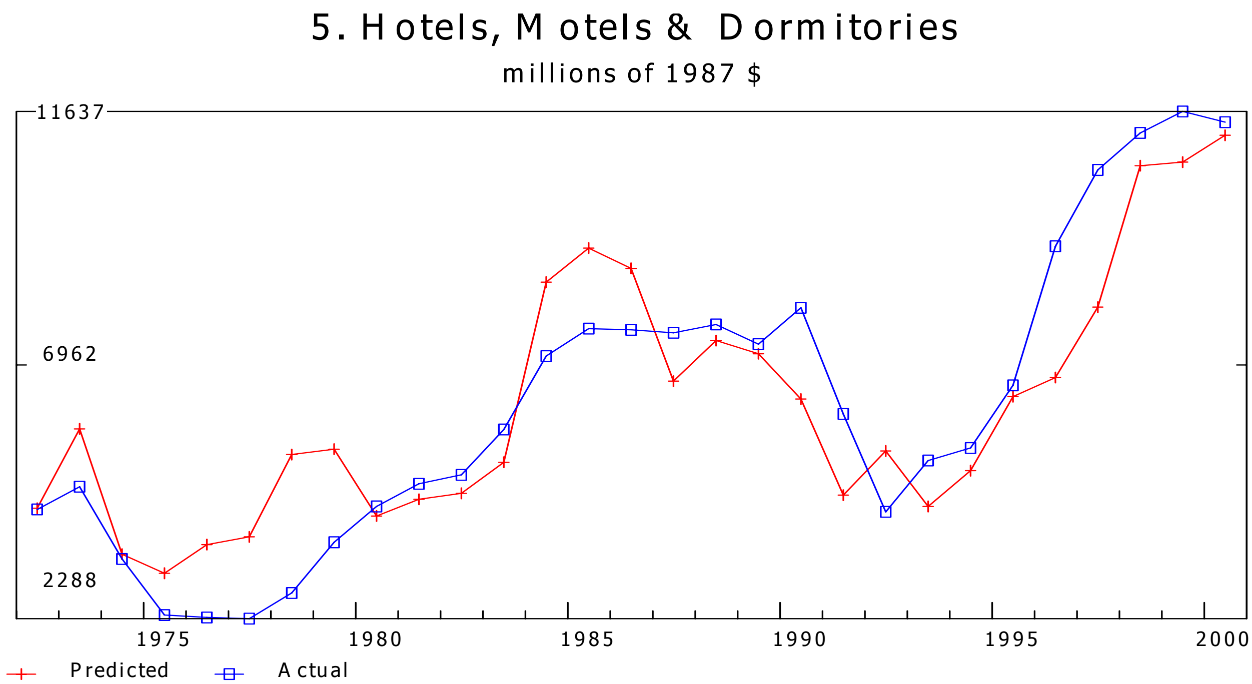
Real investment in Hotels, motels, and dormitories experienced both periods of steep decline and strong expansion in the past 25 years. Although it appears strongly procyclical, investment in this sector grew consistently amidst the sharp economic contraction in the early 1980's. Following a dramatic decline in the recession a decade later, investment grew at rates unseen in recent times. Much of this volatility is captured by five variables. Investment depends positively on the moving average of GDP. The next term is similar and measures the difference between disposable income and average disposable income. In this case, average disposable income is a four-quarter average starting with the first lag. This term may capture differences between current income and lagged permanent income, but clearly the difference cannot be classified either as permanent or transitory shocks. The fourth term is constructed as the real AAA bond rate multiplied by lagged structures stock. The amplitude of changes in this variable thus grows with the dependent variable. The result may be interpreted roughly as the user cost of capital. The final variable in this equation is changes in the real interest rate.

Figure 12

```
ti 5. Hotels, Motels & Dormitories

f draaa = raaa-raaa[1]                                # changes in raaa rate
f avgy = (di87[1]+di87[2]+di87[3]+di87[4])/4          # average di87
f difdi = (di87 - avgy)                               # di87 less average di87
f raaacstk5 = raaa*cstk5$[1]                          # interest rate * stock

con 1000000 0.0 = a2
r cst5$=gdpa,difdi,raaacstk5,draaa#draaa#,roadsetc#,cstk5$[1]
:                         5. Hotels, Motels & Dormitories
  SEE   =     1216.52 RSQ   = 0.7990 RHO =   0.54 Obser  =   29 from 1972.000
  SEE+1 =     1022.01 RBSQ  = 0.7655 DW  =   0.91 DoFree =   24 to   2000.000
  MAPE  =       20.20
    Variable name            Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 cst5$                   - - - - - - - - - - - - - - - - -   6209.06 - - -
  1 intercept              -2873.70337     3.9  -0.46    3.82       1.00
  2 avg gdp                    0.66947    17.1   0.41    2.59    3839.39  0.225
  3 d.i. - avg d.i.           23.36342    58.6   0.63    1.13     168.08  0.680
  4 aaa rate*stk of hotels     0.00064     4.5   0.42    1.07 4050909.74  0.162
  5 Δaaa bond rate          -382.03358     3.4  -0.00    1.00       0.01 -0.139
```



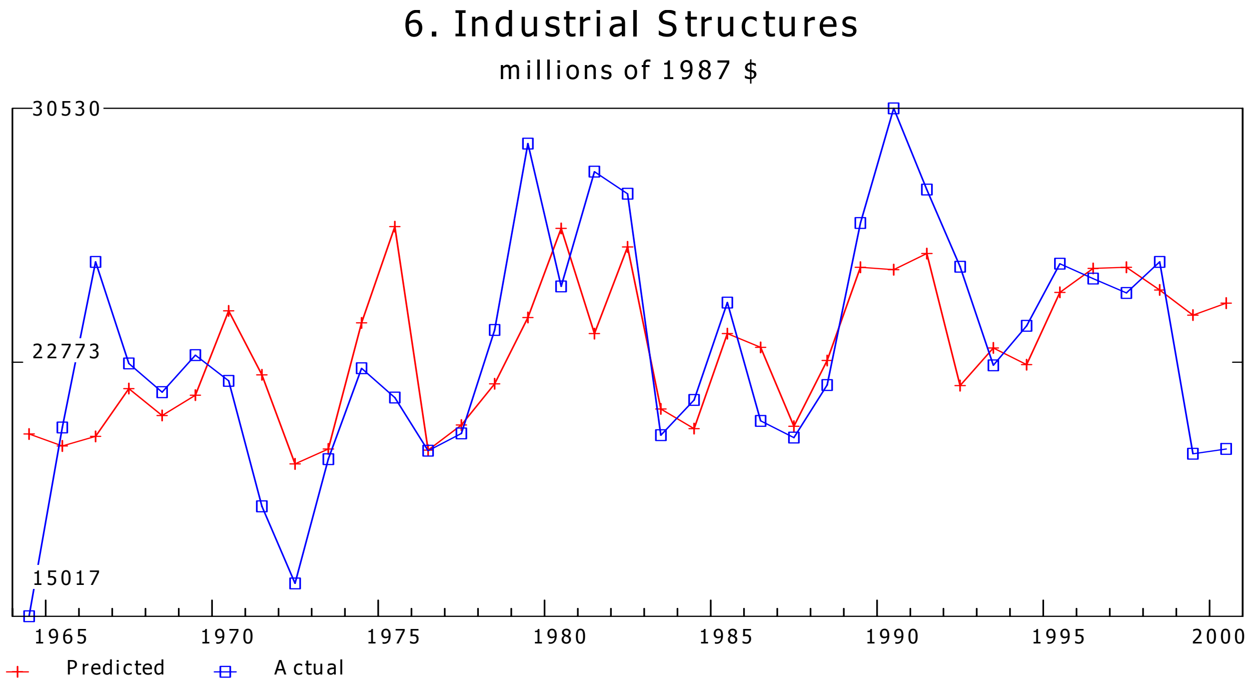
Sector 6. Industrial Structures

It often is desirable for coefficients on levels and coefficients on changes to have the same sign. In the model for Industrial structures (Sector 6), the high volatility of investment seems to be captured only by an inverse relationship with changes in output of manufacturing sectors. The coefficient for levels of output has the desired positive sign although it is small. Lagged profits also enter with a positive coefficient. Fortunately, the model seems to forecast well despite the signs. The resulting model is very simple; alternative specifications and terms yielded little improvement.

Figure 13

ti 6. Industrial Structures

```
r cst6$=outman[2],doutman,indcpr[1] #dindcpr[1]
:                             6. Industrial Structures
  SEE   =     2748.64 RSQ   = 0.3750 RHO =   0.33 Obser  =   37 from 1964.000
  SEE+1 =     2671.38 RBSQ  = 0.3182 DW  =   1.35 DoFree =   33 to   2000.000
  MAPE  =        9.36
    Variable name           Reg-Coef  Mexval  Elas    NorRes      Mean    Beta
  0 cst6$                 - - - - - - - - - - - - - - - - -  23115.45 - - -
  1 intercept             19991.69060    44.7   0.86    1.60       1.00
  2 manu. output [2]          0.91689     0.3   0.09    1.37    2237.30   0.130
  3 changes in man output   -17.06789    16.4  -0.05    1.04      62.82  -0.482
  4 manu. profits [1]        43.68986     2.2   0.09    1.00      49.09   0.365
```



Sector 7. Offices

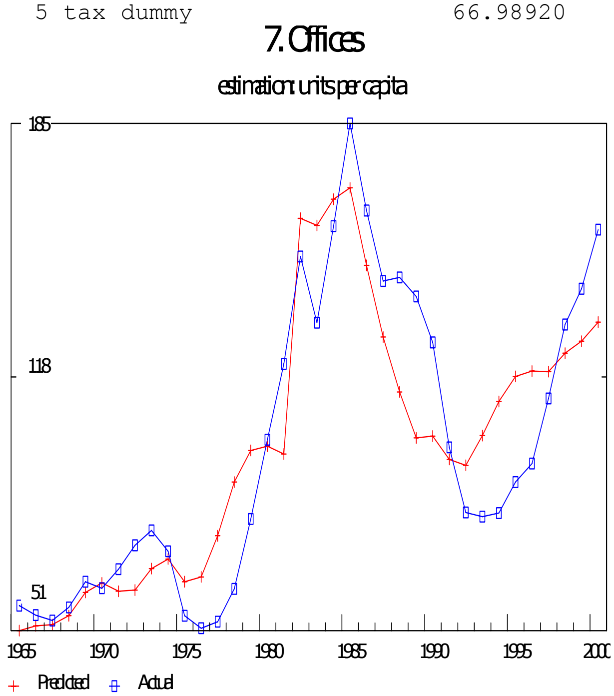
Sector 7, investment in office buildings, is estimated as investment per capita. Investment depends positively on average per capita output of business sectors, and it depends positively on lagged changes in output. The next term reflects the presence of tax incentives (ERTA) passed in 1982 and later repealed. This variable takes a value of 1.0 from 1982 to 1985. Because investment does not immediately fall to levels predicted by the other variables, the dummy is reduced linearly to achieve a value of zero in 1988. Assuming this gradual reversion greatly improves the model's performance from 1986-1988. Additional modifications of this dummy variable may improve the fit further, but most such techniques are questionable at best. The final variable is constructed to approximate floor space available to an employee in the service sectors. A negative coefficient may be expected, as shortages of floor space induce investment. The positive estimate supports this theory, since the term is constructed as the inverse of space per employee. Space is approximated as lagged stock of offices, and the number of workers is the number of employees in service sectors.

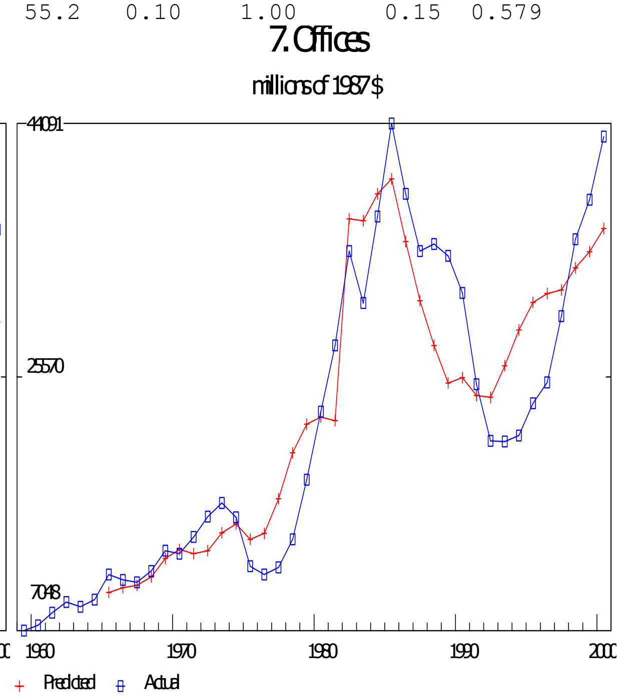
Figure 14

ti 7. Offices

```
f outbuspc=outbus/(pt/1000.)                         # Business output per capita
f outbuspca=.16*outbuspc+.34*outbuspc[1]+.34*outbuspc[2]+.16*outbuspc[3]
f doutbuspca=outbuspca-outbuspca[1]
# Inverse of floorspace per capita
  f floorcst=( empbus /(pt/1000.) ) / cstk7$[1]

r cst7pc = outbuspca, doutbuspca[2],floorcst, cst7TaxDum
:                                 7. Offices
  SEE   =      17.55 RSQ   = 0.7944 RHO =   0.74 Obser  =   36 from 1965.000
  SEE+1 =      11.98 RBSQ  = 0.7679 DW  =   0.52 DoFree =   31 to   2000.000
  MAPE  =      15.27
    Variable name              Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
  0 cst7pc                   - - - - - - - - - - - - - - - - -     99.03 - - -
  1 intercept                -106.23725     3.9  -1.07    4.86      1.00
  2 avg business output pc     13.57968    65.3   0.75    3.09      5.45  0.647
  3 Δ avg bus out pc[2]       -45.19581     1.6  -0.07    3.09      0.16 -0.085
  4 floor space / cstk    1447647.20077     6.3   1.29    2.41      0.00  0.183
  5 tax dummy                  66.98920    55.2   0.10    1.00      0.15  0.579
```





Sector 8. Stores, Restaurants, and Garages

A very simple model predicts well investment in Stores, restaurants, and garages. Such structures often are built near residential communities. Thus, the sum of investment in Sectors 1 and 2 is included, and a positive coefficient is observed. A second term is constructed as the sum of output of Retail and

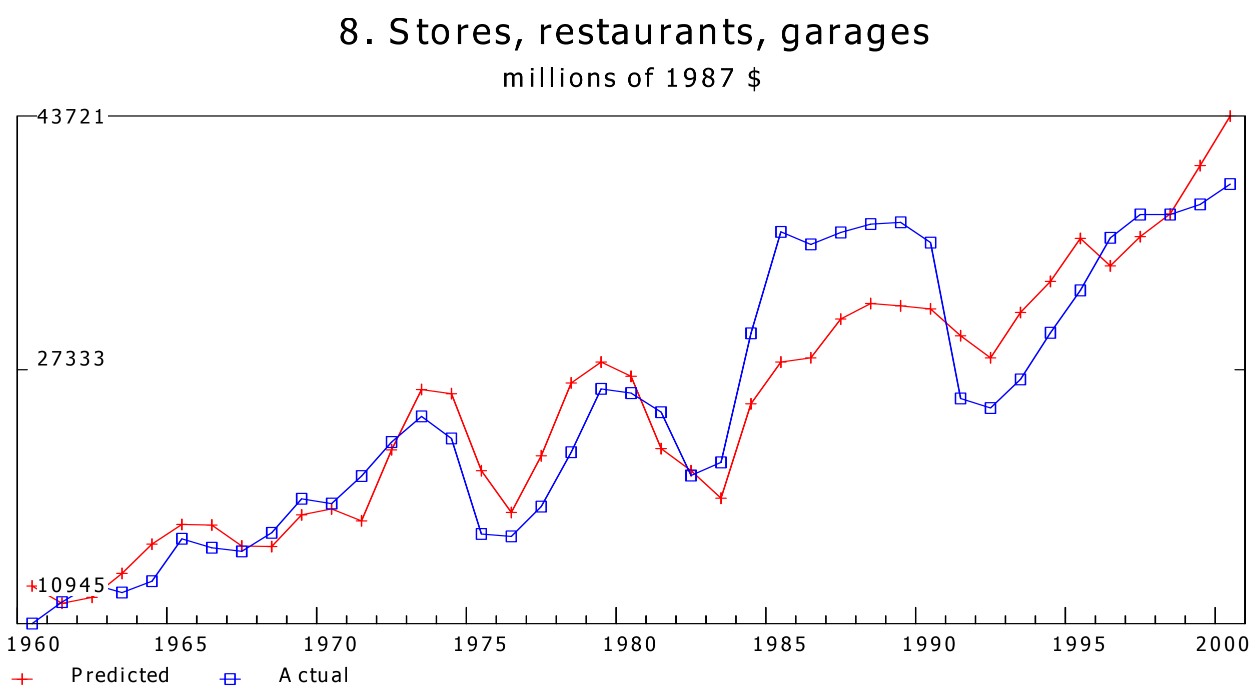
Wholesale trade and of Restaurants and bars. As expected, the coefficient on this term also is positive. Despite its simplicity, the model achieves an R-square of .85, and performs poorly only in the late 1980's.

Figure 15

```
                           ti 8. Stores, restaurants, garages

f tres = cst1$ + cst2$                   # Sum of Sector 1 and Sector 2 investment

  1 intercept               -3336.21492     2.4  -0.13    6.85      1.00
  2          0.12613    20.6   0.57    2.27 112603.78  0.371
  3   14.90471    50.8   0.56    1.00    942.42  0.621
r cst8$=tres[1],outtrade
:                         8. Stores, restaurants, garages
  SEE   =     3321.88 RSQ   = 0.8521 RHO =    0.76 Obser  =   41 from 1960.000
  SEE+1 =     2212.74 RBSQ  = 0.8443 DW  =    0.48 DoFree =   38 to   2000.000
  MAPE  =       10.61
    Variable name               Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
  0 cst8$                     - - - - - - - - - - - - - - - - -  24912.85 - - -
  1 intercept                -3532.89928     2.6  -0.14    6.76      1.00
  2 total res const[1]          0.12513    19.9   0.57    2.25 112603.78  0.368
  3 output for trade sectors   15.33601    49.9   0.58    1.00    936.08  0.621
```



Sector 9. Religious Structures

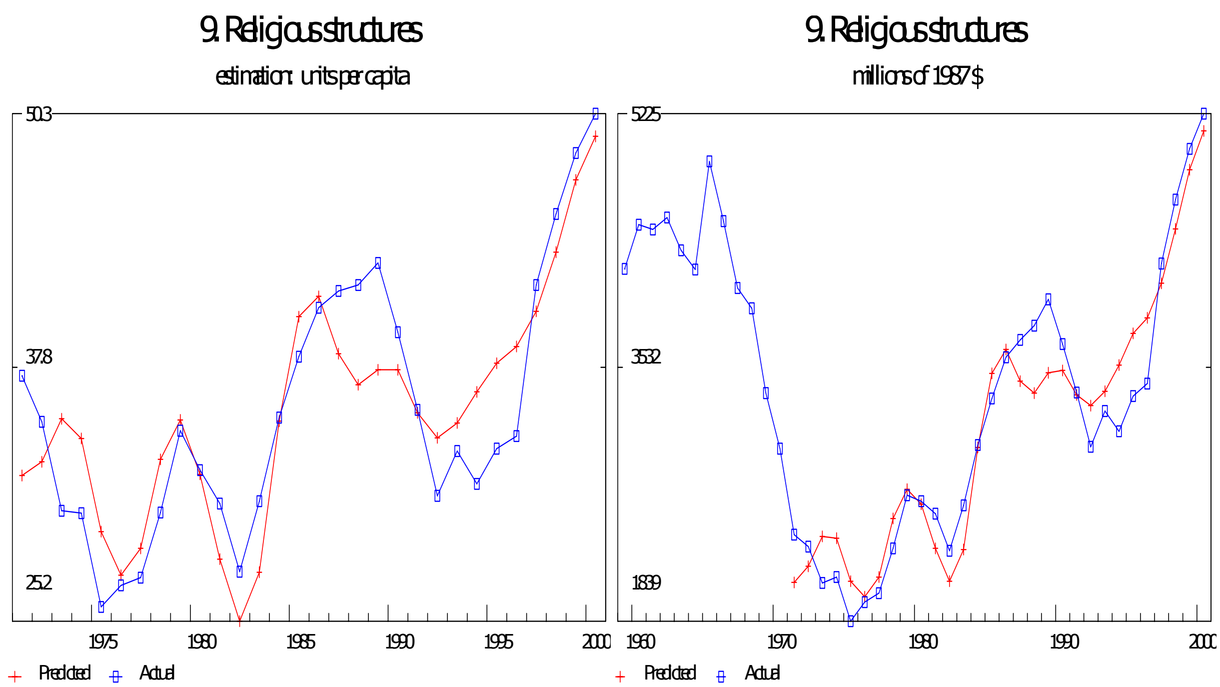
The model for Religious structures also is simple, depending only on measures of income and unemployment. Income is measured as average disposable income and its changes. Both estimated coefficients are positive. While the mexval on the unemployment rate is small, the coefficient sign is negative. This is expected, as investment in Religious structures is taken primarily from donations. Donations, in turn, likely depend on individuals' ability to give, which largely is determined by employment status and income. Unemployment rates may differ between high paying and low paying jobs, or between skilled and unskilled positions. Inclusion of both income and unemployment rates may capture implications of such differences on charitable giving and thus on investment.

Figure 16

```
                       ti 9. Religious structures

# Elder share of population
  f eldersh = 100*(gpop7+gpop8+gpop9+gpop10)/(pt/1000.)

r cst9$h = di87ha, ddi87ha, uunemp
:                            9. Religious structures
  SEE   =        2.94 RSQ   = 0.7775 RHO =    0.65 Obser  =   30 from 1971.000
  SEE+1 =        2.35 RBSQ  = 0.7518 DW  =    0.71 DoFree =   26 to   2000.000
  MAPE  =        7.22
    Variable name             Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 cst9$h                  - - - - - - - - - - - - - - - - -     35.59 - - -
  1 intercept                16.92893     8.2   0.48    4.49       1.00
  2 real avg d.i./hhld        0.43927    12.4   0.46    2.38      37.47   0.297
  3 Δ real avg d.i./hhld     10.52167    30.7   0.15    1.03       0.51   0.595
  4 unemployment rate       -37.50548     1.3  -0.09    1.00       0.09  -0.110
```



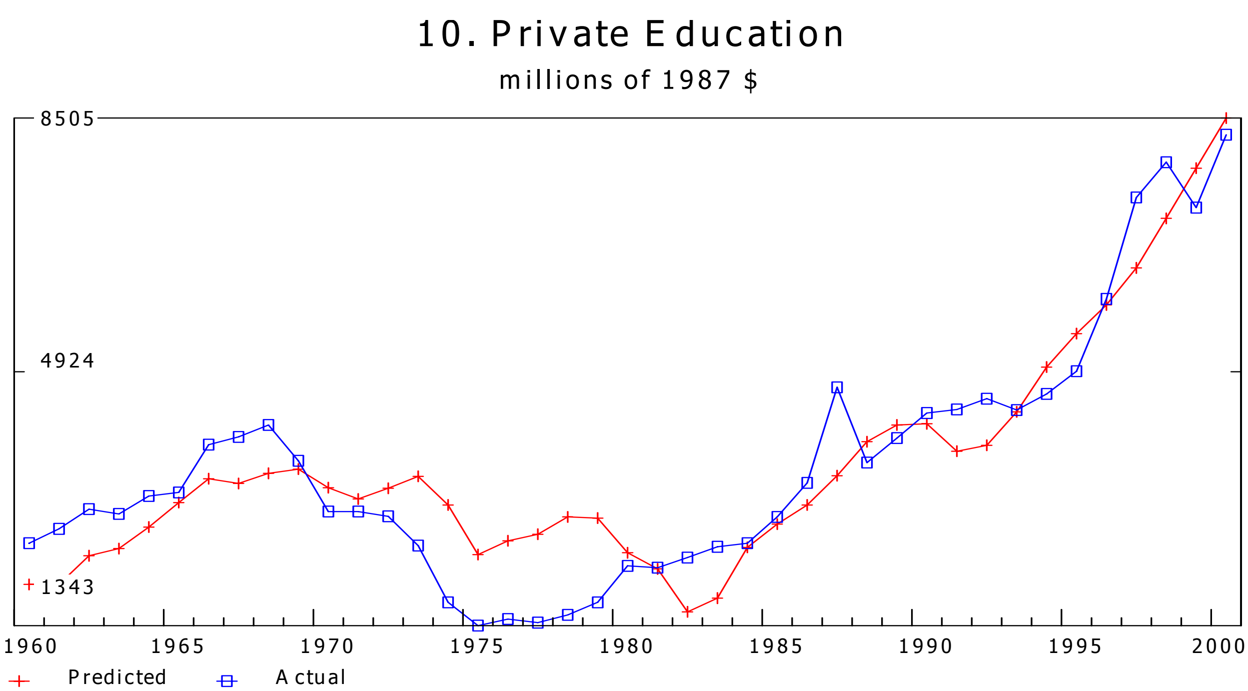
Sector 10. Educational Structures

While no such analysis has been undertaken here, a significant relationship may exist between investment in Religious structures and investment in Private educational structures, since many private educational institutions also are religious institutions. A similar model is employed for Educational structures, Sector 10, with a measure of consumer spending rather than disposable income and again the unemployment rate. Since public schools provide similar educational opportunities for lower cost, private education may be a luxury good. This supposition is supported by the negative coefficient on unemployment rates and by similar reasoning to that given for Religious structures. The relationship of investment and expenditures is positive and highly elastic. The share of the population which is of school ages also is present in the model. The estimated coefficient is positive and the relationship also is highly elastic.

Figure 17

ti 10. Private Education

```
# Young share of population
  f youngshr = 100*(gpop1+gpop2+gpop3)/(pt/1000.)
r cst10$=youngshr,pcex,unemp
:                            10. Private Education
  SEE   =      686.65 RSQ   = 0.8414 RHO =   0.71 Obser  =   41 from 1960.000
  SEE+1 =      487.21 RBSQ  = 0.8286 DW  =   0.57 DoFree =   37 to   2000.000
  MAPE  =       22.64 Test period:   SEE   762.83 MAPE     4.67 end  2015.000
    Variable name           Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
  0 cst10$                 - - - - - - - - - - - - - - - - -  3596.55 - - -
  1 intercept            -13175.59438     6.8  -3.66    6.31      1.00
  2 young share             329.10557     8.8   3.03    5.00     33.06  0.804
  3 personal consumption      2.80199    55.8   2.02    1.09   2598.43  1.623
  4 unemployment rate        -0.22110     4.3  -0.39    1.00   6286.62 -0.274
```



Sector 11. Hospital and Institutional Structures

The regression model for Sector 11, Hospitals and institutional structures, depends on three exogenous terms. Data for these terms are taken from the Statistical Abstract of the United States. These data end in 1998. Values then are projected as linear trends with rho adjustments. While the trends are determined by regressions, the estimation ranges were chosen to yield reasonable forecast paths. The first variable is for days of care. The level of this series was very high in the 1970's. It fell dramatically between 1980 and 1995, and it then leveled off. Projected values thus continue to fall slightly, but they remain approximately equal to those values of the late 1990's.

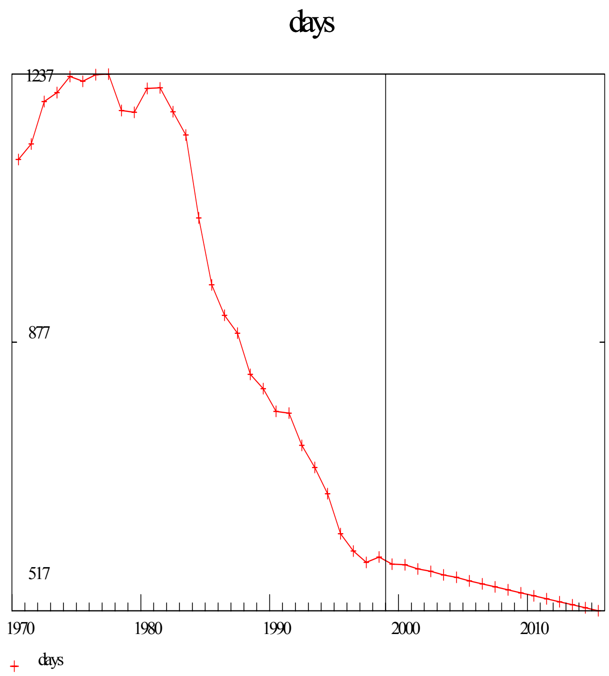
Figure 18a
ti days

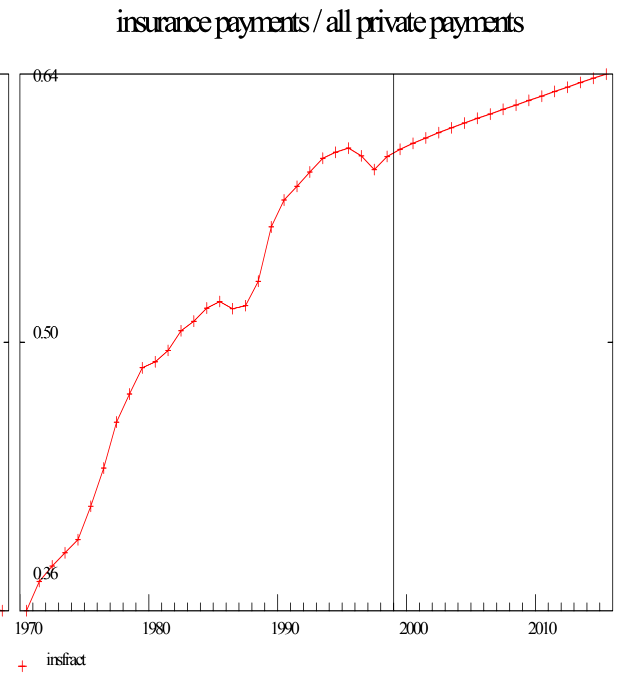
```
r days=time
:                                  patients
  SEE   =        5.19 RSQ   = 0.2840 RHO =  -0.50 Obser  =    3 from 1996.000
  SEE+1 =        3.82 RBSQ  = -0.4320 DW  =   3.00 DoFree =    1 to   1998.000
  MAPE  =        0.83
    Variable name           Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
  0 days                  - - - - - - - - - - - - - - - - -    589.33 - - -
  1 intercept              745.33333   217.0   1.26    1.40      1.00
  2 time                    -4.00000    18.2  -0.26    1.00     39.00 -0.533
```

The second exogenous variable is the fraction of private payments which are paid by insurance companies. This fraction has grown steadily for forty years, although the ratio fell slightly in the mid-1990's. The series is projected to climb in the future but more slowly than the historical rate.

Figure 18b
ti insurance payments / all private payments

```
r insfract=time
:                                    days
  SEE   =        0.01 RSQ   = 0.4963 RHO =   0.65 Obser  =    9 from 1990.000
  SEE+1 =        0.01 RBSQ  = 0.4244 DW  =   0.70 DoFree =    7 to   1998.000
  MAPE  =        0.92
    Variable name           Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
  0 insfract              - - - - - - - - - - - - - - - - -      0.59 - - -
  1 intercept                0.50902   506.0   0.86    1.99      1.00
  2 time                     0.00234    40.9   0.14    1.00     36.00  0.705
```



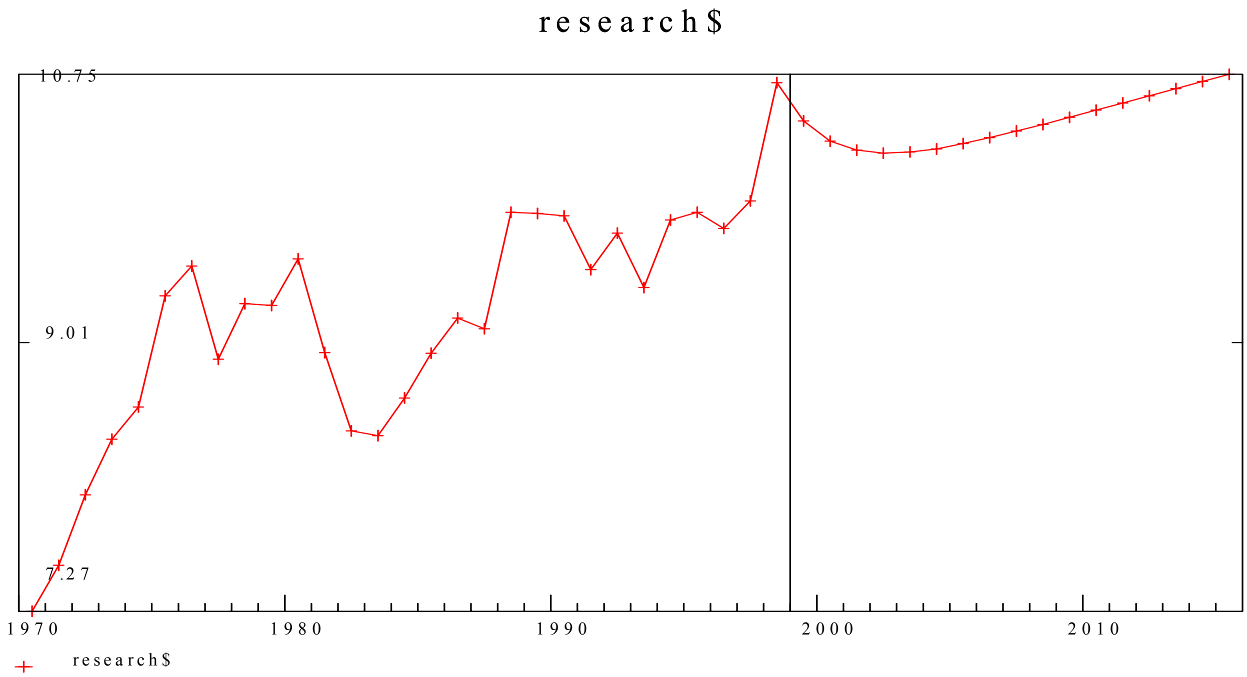


The final exogenous variable is real spending on medical research. Spending has been trending upward but also has been volatile. The trend thus has been estimated over all available periods, 1975 to 1998. While spending in 1998 was well above the trend, research funding is projected to fall until 2002 as it converges smoothly with the trend.

Figure 18c

```
                              ti research$

r research$=time
:                                  Compare
  SEE    =        0.40 RSQ    = 0.3974 RHO =    0.61 Obser   =    24 from 1975.000
  SEE+1  =        0.34 RBSQ   = 0.3700 DW  =    0.78 DoFree  =    22 to   1998.000
  MAPE   =        3.54
    Variable name            Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 research$              - - - - - - - - - - - - - - - - -       9.40 - - -
  1 intercept                8.04680    380.3   0.86    1.66       1.00
  2 time                     0.04743     28.8   0.14    1.00      28.50  0.630
```



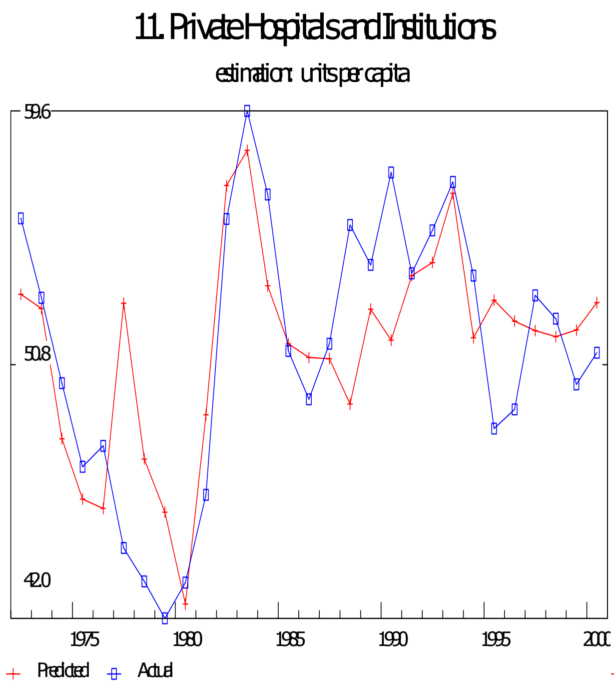
These exogenous variables, together with several terms endogenous to the *IDLIFT* model, are used to model per capita investment in Private Hospitals and institutional structures. In this regression model, public spending has been added to private investment. Since private spending dwarfs public investment, the coefficients probably also are reasonable for private investment alone. Later work will investigate separate models for private and for public investment. Investment is estimated with positive coefficients on lagged personal consumption expenditures on hospitals and on changes in spending. Changes in the fraction of payments covered by insurance also have a positive effect on investment. Real research per capita may be a substitute for investment in structures since its coefficient is negative and its mexval is high. Changes in the real interest rate are negatively related to investment. Finally, the coefficient is positive on the change in days of care per capita. Of course, this last term is related closely to changes in the average length of stay measured over patients only. It seems several of the independent variables conspire in 1977 to yield an unusually large predicted increase. Attempts to lessen the jump caused other problems and had little effect on the 1977 prediction. Hence, it seems better to accept the unusual result until a superior model can be constructed.

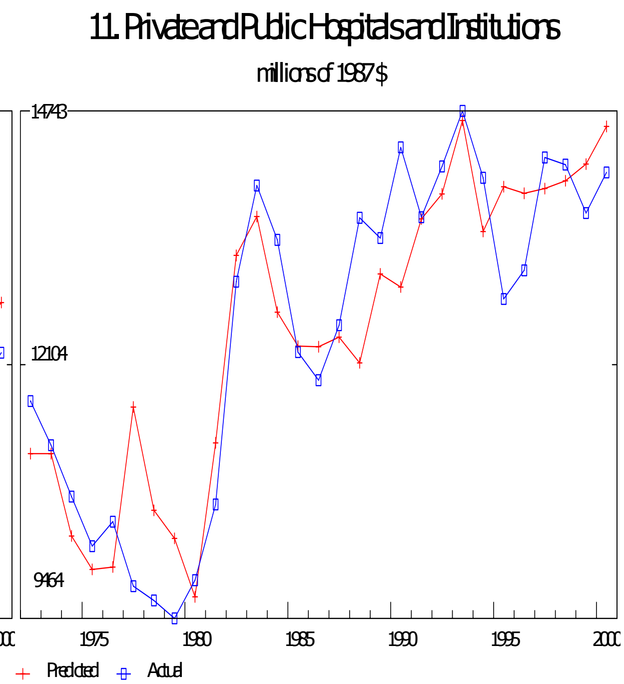
Figure 19

ti 11. Private Hospitals and Institutions

```
f tot11 = cst11$+gs11      # Private and public construction

r tot11pc=pce50pc[1],dpce50pc[2],dinsfract,research$pc,draaa,ddayspc[1]
:                      11. Private Hospitals and Institutions
  SEE   =        3.00 RSQ   = 0.5699 RHO =   0.27 Obser  =   29 from 1972.000
  SEE+1 =        2.90 RBSQ  = 0.4527 DW  =   1.46 DoFree =   22 to   2000.000
  MAPE  =        4.56
    Variable name              Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 tot11pc                   - - - - - - - - - - - - - - - - -    51.41 - - -
  1 intercept                113.78461    50.9   2.21    2.33       1.00
  2 pce(50) p.c.[1]            0.00332     0.4   0.04    2.12     646.11  0.082
  3 Δpce(50) p.c.[2]           0.04560     0.3   0.01    2.12      14.95  0.089
  4 change in ins fraction   161.01794     4.7   0.03    2.12       0.01  0.279
  5 research p.c.             -1.68813    25.0  -1.27    1.18      38.82 -0.747
  6 Δraaa                     -1.53727     7.1  -0.00    1.09       0.01 -0.332
  7 Δdayspc[1]              8092.75408     4.3  -0.02    1.00      -0.00  0.253
```





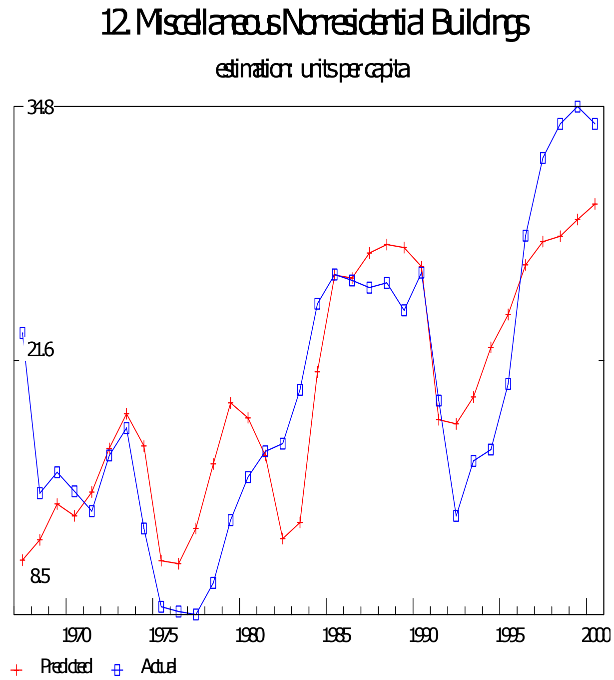
Sector 12. Miscellaneous Nonresidential Buildings

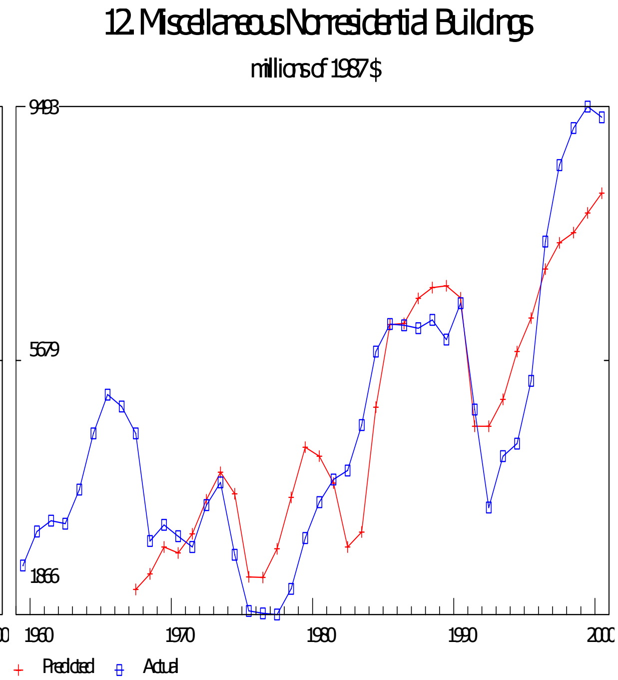
Miscellaneous Nonresidential Buildings, Sector 12, includes various items such as investment in passenger terminals, greenhouses, recreational buildings, and animal hospitals. Per capita investment is estimated using construction in Sector 8, Stores, restaurants, and garages, as an estimate of demand. A second measure of demand is disposable income per capita. The coefficient is reduced to 0.82 by a constraint; without the constraint, forecasted investment is unreasonably high. Finally, investment depends negatively on real interest rates.

Figure 20

ti 12. Miscellaneous Nonresidential Buildings

```
con 10 .7=a2
r cst12pc=di87pc, cst8pc, raaa[1]
:                   12. Miscellaneous Nonresidential Buildings
  SEE   =       4.09 RSQ   = 0.6904 RHO =   0.75 Obser  =   34 from 1967.000
  SEE+1 =       3.23 RBSQ  = 0.6594 DW  =   0.50 DoFree =   30 to   2000.000
  MAPE  =      19.10 Test period:   SEE     1.87 MAPE     3.87 end  2015.000
    Variable name           Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 cst12pc               - - - - - - - - - - - - - - - - -     19.91 - - -
  1 intercept               -8.52843     5.7  -0.43    3.52      1.00
  2 d.i. p.c.                0.74976    20.4   0.50    1.98     13.26  0.265
  3 const(8) pc              0.19003    40.7   1.09    1.04    113.94  0.621
  4 aaa bond rates[1]       -0.36161     1.8  -0.16    1.00      8.73 -0.106
```





Sector 13. Farm Buildings

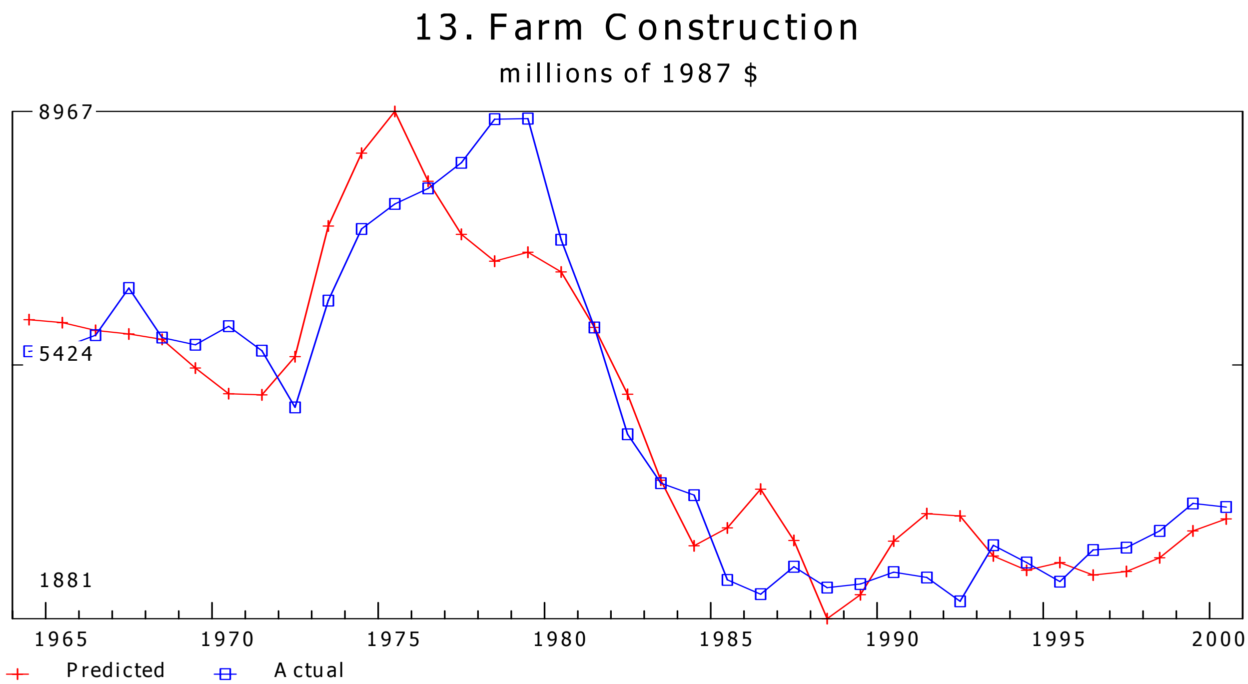
Real Farm construction is the only sector experiencing negative growth over the last four decades. Fortunately, spending has stabilized since the mid-1980's and even has resumed a slightly positive trend. Investment is estimated using agricultural output, interest rates, and agricultural prices relative to the GDP deflator. Output is average agricultural production; its levels and changes have positive coefficients. Real interest rates have a negative coefficient, and agricultural prices have positive coefficients. The distributed lag on prices was smoothed with a soft constraint.

Figure 21

```
                              ti  13. Farm Construction

f dagrica = agrica-agrica[1]                     # Change in agricultural output

sma 10 a5 a7 1 f
r cst13$= agrica,dagrica,raaa, fpr, fpr[1],fpr[2]
:                              13. Farm Construction
  SEE   =      772.13 RSQ   = 0.8662 RHO =    0.59 Obser  =   37 from 1964.000
  SEE+1 =      625.37 RBSQ  = 0.8395 DW  =    0.82 DoFree =   30 to   2000.000
  MAPE  =       14.44
    Variable name            Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
  0 cst13$                  - - - - - - - - - - - - - - - - -   4711.24 - - -
  1 intercept             -6942.47955    14.5  -1.47    7.45       1.00
  2 avg ag output             0.00621     0.9   0.23    4.05 174028.71  0.111
  3 Δavg ag output            0.21471    10.5   0.17    3.71   3819.86  0.254
  4 aaa bond rates         -184.43805     9.2  -0.33    3.62       8.47 -0.200
  5 relative prices          31.19890    13.2   0.80    1.86     121.07  0.417
  6 relative prices[1]       26.10584     7.5   0.68    1.32     122.59  0.340
  7 relative prices[2]       34.92326    14.8   0.92    1.00     124.19  0.442
```



Sector 14. Mining Exploration Shafts and Wells

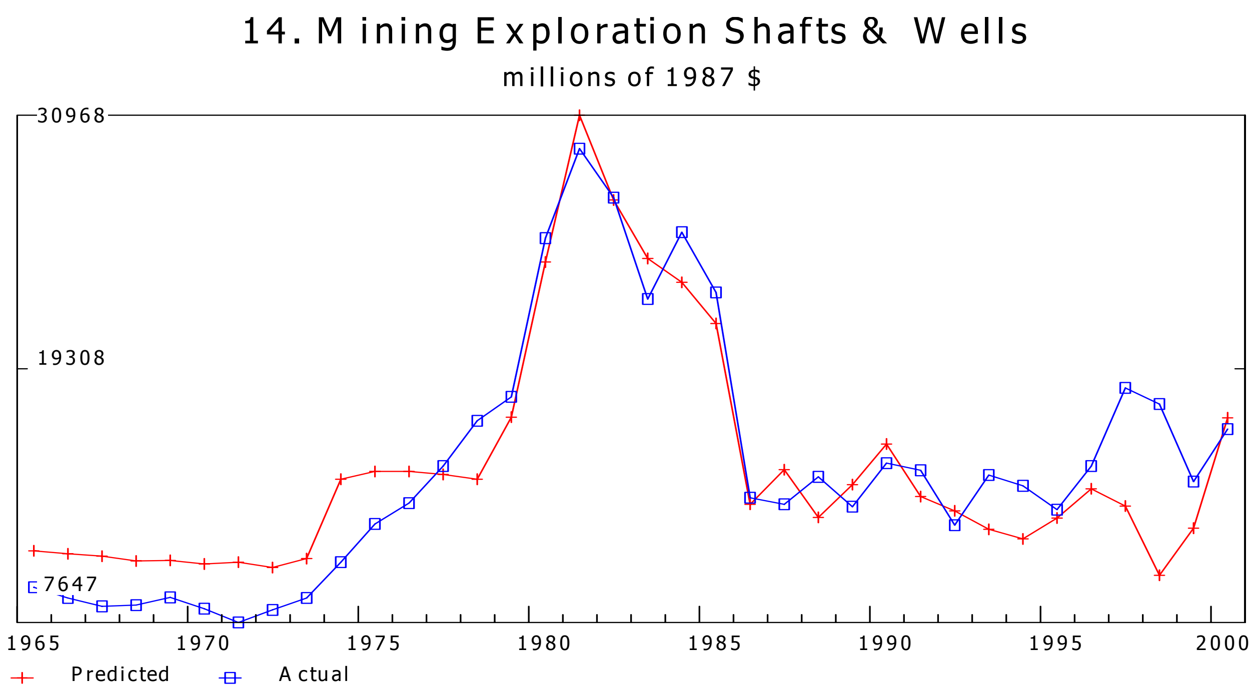
Figure 21 depicts data for Mining exploration shafts and wells. In this equation, investment depends positively on the relative price of oil and positively on changes in lagged average mining output. Both reflect demand for minerals and thus demand for structures in this category. While the mexvals indicate that changes in output do not contribute to the fit of the equation, the presence of a constraint weakens such a conclusion.

Figure 22

```
                          ti 14. Mining Exploration Shafts & Wells

f outmina=.16*outmin+.34*outmin[1]+.34*outmin[2]+.16*outmin[3]
f doutmina=outmina-outmina[1]

con 350 10.=a3
r cst14$=rpoil,doutmina[2]#,rcbr,drpoil[1]
:                      14. Mining Exploration Shafts & Wells
  SEE   =     2374.92 RSQ   = 0.8257 RHO =   0.59 Obser  =   36 from 1965.000
  SEE+1 =     1924.14 RBSQ  = 0.8151 DW  =   0.81 DoFree =   33 to   2000.000
  MAPE  =       14.86
    Variable name           Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
  0 cst14$                 - - - - - - - - - - - - - - - - -  14797.67 - - -
  1 intercept             4480.91784    30.5   0.30    5.68       1.00
  2 relative oil prices    101.86362   137.9   0.70    1.00     101.29  0.908
  3 Δavg mining output[2]   -3.06341     0.0  -0.00    1.00       0.23 -0.002
```



Sector 15. Railroads

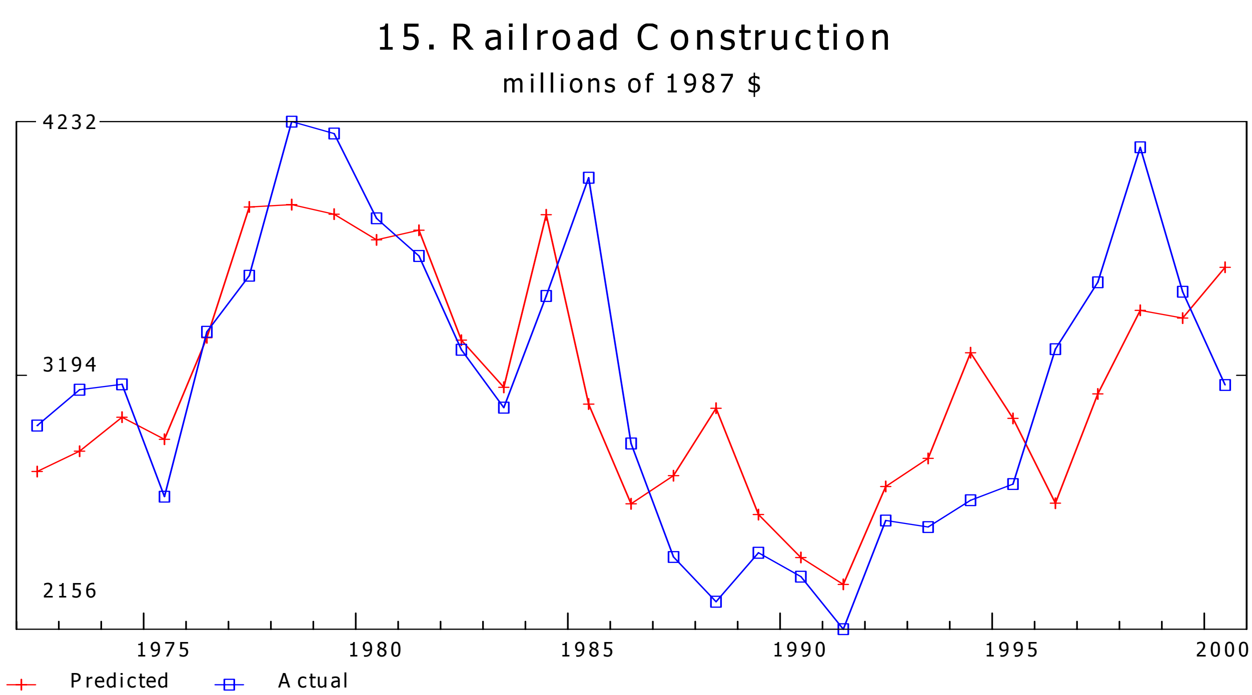
Real railroad construction was quite low from 1986 to 1995, but investment levels have been higher in the last five years. Investment depends positively on the average relative price of oil, output in the railroad sector, and on changes in GDP. Investment depends negatively on public spending on highways and streets, which may substitute for railroads, and on lagged real interest rates. While both locomotives and trucks may use oil and thus may be affected by oil prices, trains are relatively more efficient and thus railroads may be a substitute for trucks when oil is expensive. Also, passengers may travel by rail rather than by air or automobile during periods of high prices.

Figure 23

```
                         ti 15. Railroad Construction

# Average relative oil prices
  f rpoilavg = .16*rpoil[1]+.34*rpoil[2]+.34*rpoil[3]+.16*rpoil[4]

 r cst15$ = gs20$,rpoilavg, out59$,rcbr[1],dgdp
:                            15. Railroad Construction
  SEE   =      378.86 RSQ   = 0.5865 RHO =    0.32 Obser  =   29 from 1972.000
  SEE+1 =      361.94 RBSQ  = 0.4966 DW  =    1.36 DoFree =   23 to   2000.000
  MAPE  =        9.77
    Variable name              Reg-Coef  Mexval  Elas    NorRes     Mean   Beta
  0 cst15$                   - - - - - - - - - - - - - - - - -   3161.36 - - -
  1 intercept                2493.95149     8.0   0.79     2.42      1.00
  2 roads                      -0.11235     7.9  -1.02     2.29  28706.71 -0.871
  3 avg relative oil price      9.18862     9.0   0.32     2.29    108.55  0.751
  4 railroad output             0.10627    18.4   1.16     1.60  34641.49  1.191
  5 real corp bus rates[1]   -243.39476    21.3  -0.34     1.13      4.41 -1.038
  6 Δgdp                        1.93440     6.3   0.09     1.00    148.76  0.324
```

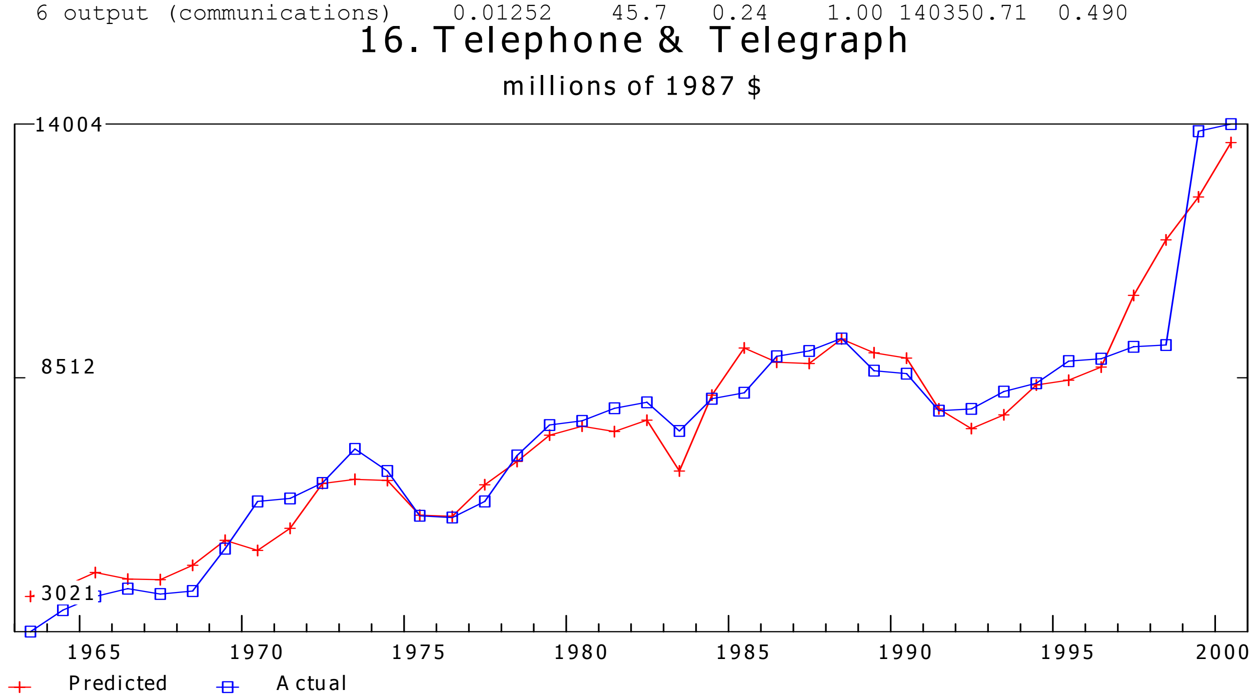


Sector 16. Telephone and Telegraph

Investment in Sector 16, Telephone and Telegraph, grew steadily before exploding in the late 1990's. As might be expected, much of this behavior is explained by measures of demand and by interest rates. Coefficients are positive on the following demand variables: current and lagged residential construction, construction of office buildings, and output in the communications services sector. The coefficient is negative on real rates on corporate bonds. Construction of homes and offices may account for much of the investment demand for telephones; hence, these variables are included in the equation. The high mexval on construction of offices supports this belief, but there exists less evidence regarding construction of homes. Of course, the latter effect may be captured in output of communication sectors, which has a high mexval.

Figure 24

```
                             ti 16. Telephone & Telegraph
f outcomm=out65                          # Output in communications services
f outcomma=.16*outcomm+.34*outcomm[1]+.34*outcomm[2]+.16*outcomm[3]
f doutcomma=outcomma-outcomma[1]
r cst16$=tres,tres[1],cst7$,rcbr[1],outcomma
:                           16. Telephone & Telegraph
  SEE   =      638.94 RSQ   = 0.9294 RHO =    0.18 Obser  =    38 from 1963.000
  SEE+1 =      631.66 RBSQ  = 0.9184 DW  =    1.65 DoFree =    32 to   2000.000
  MAPE  =        6.77
    Variable name             Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 cst16$                   - - - - - - - - - - - - - - - - -   7296.03 - - -
  1 intercept               1225.87824     4.7   0.17   14.17       1.00
  2 total res constr           0.01530     5.8   0.25    7.26 117682.60  0.158
  3 total res constr[1]        0.00532     0.6   0.08    5.90 115504.43  0.053
  4 construction(7)            0.13658    46.0   0.43    2.31  22930.97  0.613
  5 real corp bus rates     -310.13856    15.6  -0.17    2.12      3.98 -0.301
  6 output (communications)    0.01252    45.7   0.24    1.00 140350.71  0.490
```



Sector 17. Electric Light and Power

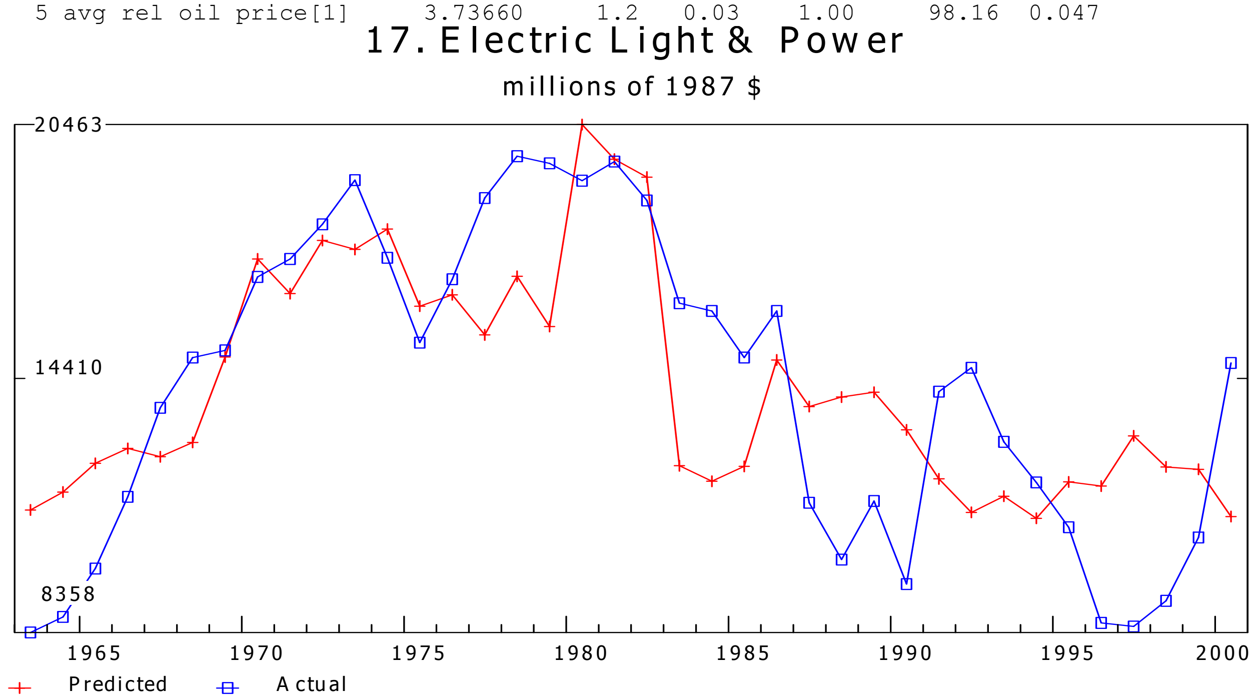
Modeling investment in Electric light and power structures has proven somewhat difficult. While this regression model captures the basic pattern of investment, periods of poor performance suggest the importance of omitted variables. Such variables undoubtedly include environmental regulations and other policy variables. In this model, the average relative price of oil enters with a positive coefficient. This may imply that oil and electricity are substitutes or that higher input prices for oil-fired plants spur investment to improve efficiency. Demand is estimated by the average percentage change in the number of households and by the average output of electric utilities. Coefficients on these demand terms are positive. Interest rates multiplied by the stock of structures are inversely related to investment. Of these explanatory variables, oil prices and growth in the number of households seem explain most of the variation in investment. Caution is required, however, as the estimated coefficient on oil prices is rather large. This causes investment in power plants to respond too strongly, or at least too quickly, to changes in oil prices. For this reason, the parameter on oil prices was reduced with a soft constraint.

Figure 25

```
ti 17. Electric Light & Power

f pcht = ((hhld/hhld[1])-1.)*100.       # Percentage change in number of households
f avgpch = (pcht+pcht[1]+pcht[2])/3.    # Average pcht
f rltrend$17 = rcbr*cstk17$[1]/1000.    # Interest rate times stock

con 10000 0. = a5
r cst17$=avgpch,out66a,rltrend$17,rpoa
:                          17. Electric Light & Power
  SEE   =     2453.85 RSQ   = 0.5444 RHO =   0.60 Obser  =   38 from 1963.000
  SEE+1 =     2023.21 RBSQ  = 0.4891 DW  =   0.81 DoFree =   33 to   2000.000
  MAPE  =       16.98
    Variable name           Reg-Coef  Mexval  Elas   NorRes      Mean    Beta
  0 cst17$                 - - - - - - - - - - - - - - - - -  14204.18 - - -
  1 intercept              2339.83943     1.1   0.16     2.14       1.00
  2 avg %Δhhld             5226.14173    37.9   0.64     1.12       1.74  0.805
  3 avg utility output        0.01787     2.8   0.18     1.03 139986.33  0.233
  4 int rate * stock(17)     -0.01816     0.0  -0.01     1.02    5141.57 -0.017
  5 avg rel oil price[1]      3.73660     1.2   0.03     1.00      98.16  0.047
```



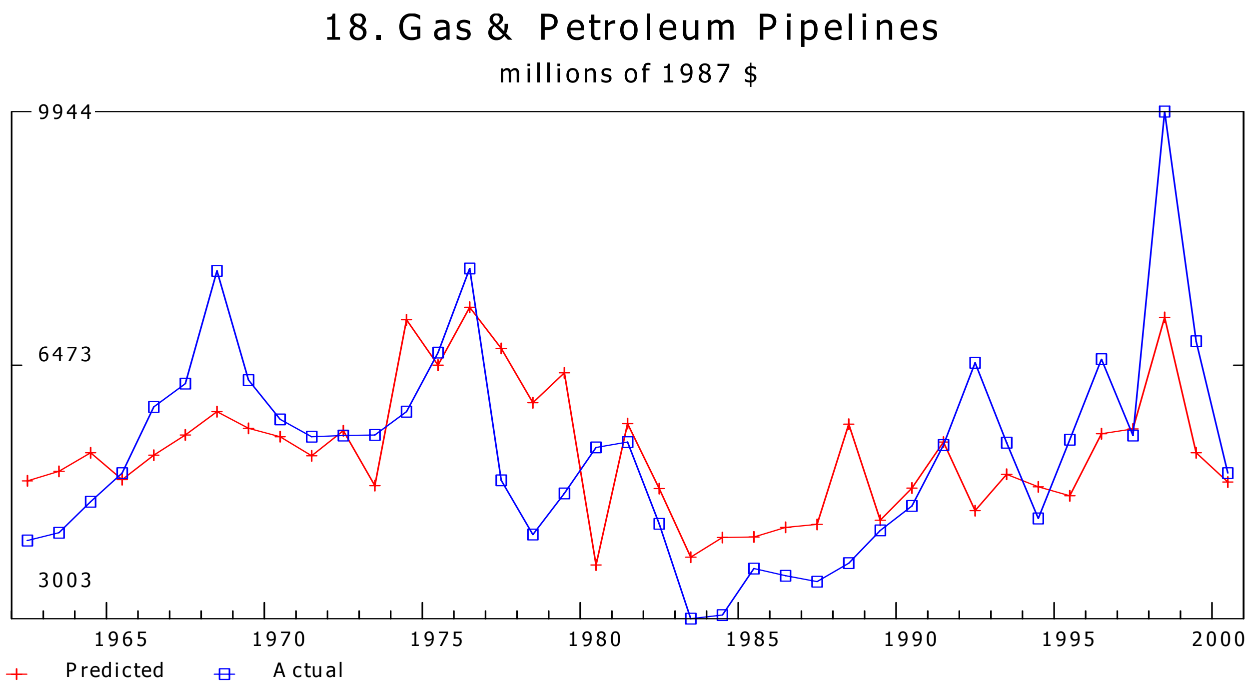
Sector 18. Gas and Petroleum Pipes

Investment in structures for Gas and petroleum pipelines followed a peculiar and volatile path since the mid-1960's, as is shown in Figure 26. Sector 18 may depend on unspecified policy variables, as was suggested also for Sector 17. Such changes in policies may explain the spikes in investment in 1968 and 1975. Notable also was the large increase in 1998. These dramatic increases are matched by immediate and dramatic decreases. This volatility is difficult to capture with a simple linear model. As may be expected, the adjusted R-square is low (0.39). Interest rates and changes in output of petroleum refining prove most useful in estimating investment. Output in the pipeline sector and changes in relative oil prices are less useful. Nevertheless, coefficient signs are in accordance with theory. The performance of this model may improve if large projects, such as construction of the Alaskan pipeline in the mid-1970's, were identified and incorporated using dummy variables.

Figure 26

ti 18. Gas & Petroleum Pipelines

```
r cst18$=rcbr,doutgas,out63$[1],drpoil[1]
:                          18. Gas & Petroleum Pipelines
  SEE   =     1070.18 RSQ   = 0.3970 RHO =   0.35 Obser  =   39 from 1962.000
  SEE+1 =     1004.32 RBSQ  = 0.3260 DW  =   1.29 DoFree =   34 to   2000.000
  MAPE  =       16.35
    Variable name             Reg-Coef  Mexval  Elas   NorRes     Mean   Beta
  0 cst18$                   - - - - - - - - - - - - - - - - -   5269.67 - - -
  1 intercept                4760.26080    42.4   0.90    1.66      1.00
  2 corp bond rate           -203.58631     7.4  -0.16    1.41      4.02 -0.343
  3 Δoutput (gas)               0.12412    16.8   0.06    1.17   2601.86  0.510
  4 pipeline output[1]          0.14010     2.1   0.19    1.12   7158.62  0.180
  5 Δrelative oil price[1]     15.72440     5.7   0.00    1.00      0.13  0.286
```



Sector 19. Other Private Structures

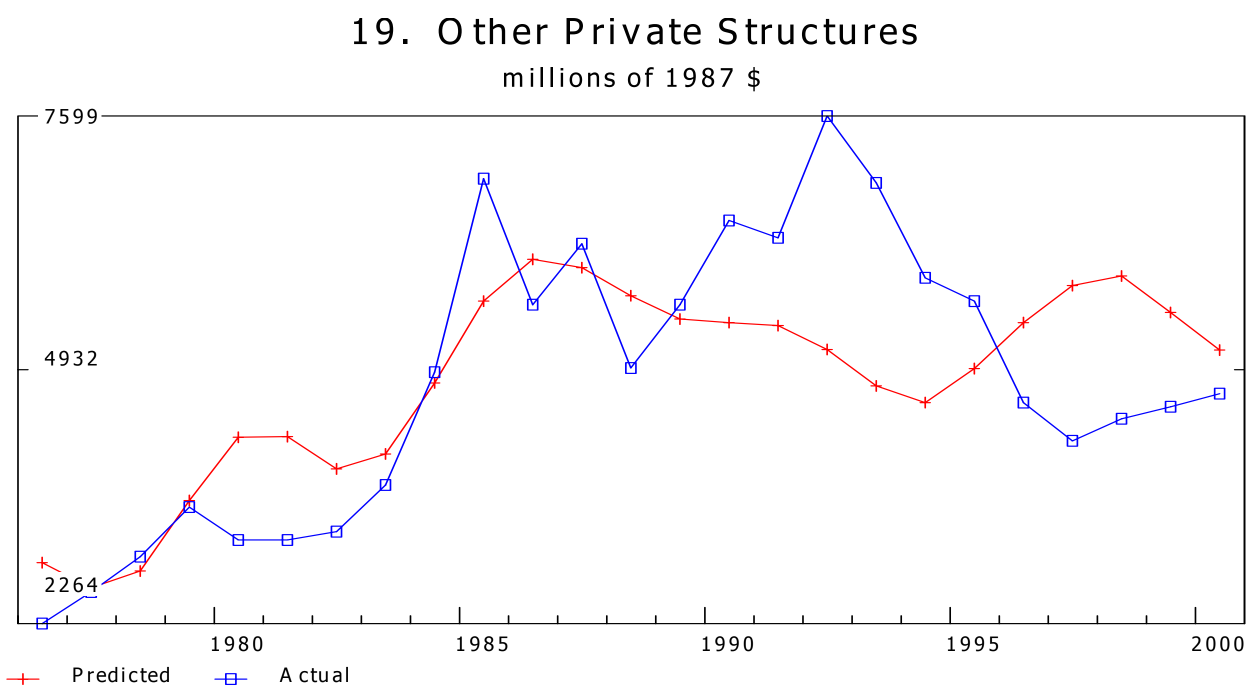
Sector 19, Other private structures, includes investment in private streets, dams, parks, and airfields. Average personal consumption and its changes are used as direct measures of demand. Fit of the data improves greatly when the coefficient for changes in consumption is not constrained. For reasonable simulations and forecasting, however, the coefficient should be "less negative" than the coefficient for levels of consumption is positive. Two measures of government spending also are included: (1) levels of and changes in public spending on Highways and streets and (2) changes in average government spending on nondefense structures. Whether correlation between private investment and public spending results from cooperation on the same projects, from one type of spending following the other in the same geographic area, or exists simply because both types of investment are determined by the same economic events, it seems consideration of public spending significantly improves estimation for this sector.

Figure 27

```
                        ti 19.  Other Private Structures

# Average personal consumption expenditures
  f pcexa=.16*pcex+.34*pcex[1]+.34*pcex[2]+.16*pcex[3]
  f dpcexa = pcexa-pcexa[1]
# Government spending on structures
  f gconstr = gslstr+gfndstr
  f gconstra=.16*gconstr+.34*gconstr[1]+.34*gconstr[2]+.16*gconstr[3]
  f dgconstra=gconstra-gconstra[1]
# Government spending on Highways and streets
  f gs20a = .16*gs20+.34*gs20[1]+.34*gs20[2]+.16*gs20[3]
  f dgs20a = @diff(gs20a)

con 10000  0. = a5
r cst19$=gs20a,dgs20a,pcexa,dpcexa[1],
dgconstra#,dpcexa[2],dpcexa[3],dpcexa[4],dpcexa[5]#,dgconstra
:                          19.  Other Private Structures
  SEE    =    1048.83 RSQ   = 0.4866 RHO =    0.69 Obser  =   25 from 1976.000
  SEE+1  =     762.88 RBSQ  = 0.3514 DW  =    0.61 DoFree =   19 to   2000.000
  MAPE   =      17.56
    Variable name           Reg-Coef  Mexval  Elas   NorRes      Mean   Beta
  0 cst19$                 - - - - - - - - - - - - - - - - -   4801.93 - - -
  1 intercept             5441.19933    14.4   1.13    1.92       1.00
  2 gs20a                   -0.23330     6.2  -1.38    1.78   28349.31 -0.670
  3 dgs20a                   1.33830     4.8   0.11    1.28     380.84  0.788
  4 pcexa                    1.91849    10.6   1.23    1.04    3067.09  0.912
  5 dpcexa[1]               -1.33274     0.8  -0.03    1.02      92.01 -0.035
  6 dgconstra             -221.68249     1.2  -0.06    1.00       1.34 -0.423
```



Forecast

The following graphs display data and forecasts for the new equations and for a previous (April 2001) version of *IDLIFT*. Although the data are similar, the newly-constructed series for structures are not identical to those used before. The primary change is the use of NIPA-consistent construction prices instead of "input/output" prices. Most deflated series are similar but are not exactly the same. Other differences also exist in data construction, but most are minor. The final period for the new series is 2000; the last period for the old data, used in the April forecast, is 1997. Therefore, the different starting points explain some of the differences in the forecasts; that is, the April 2001 model predicted values for 1998-2000, while the new equations incorporate actual data. All forecasts are subject to rho-adjustment fixes; the same adjustment parameters are used for both models. No other fixes are placed on the new structures equations.

Figure 28 shows that expected construction shares, for residential, nonresidential, and total private construction, are expected to stabilize and fall only slightly through 2010. Further analysis is required to explain this phenomena; a comparison of growth among other final demand components could illuminate the matter.

Figure 28

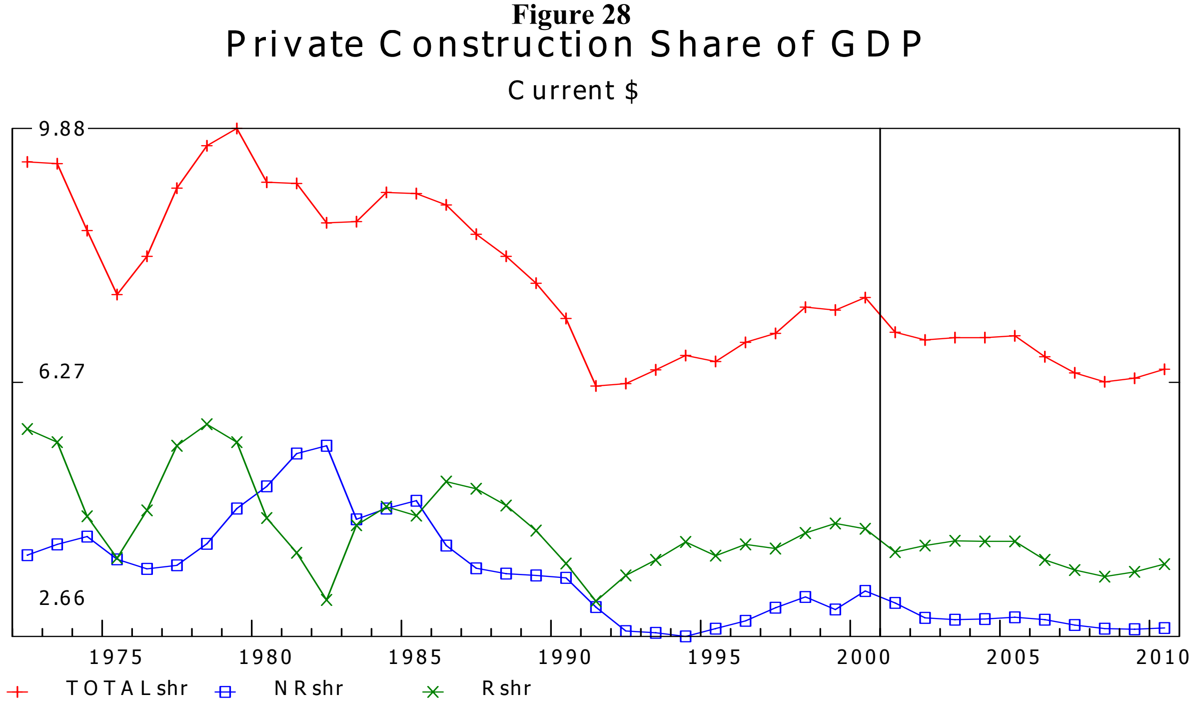
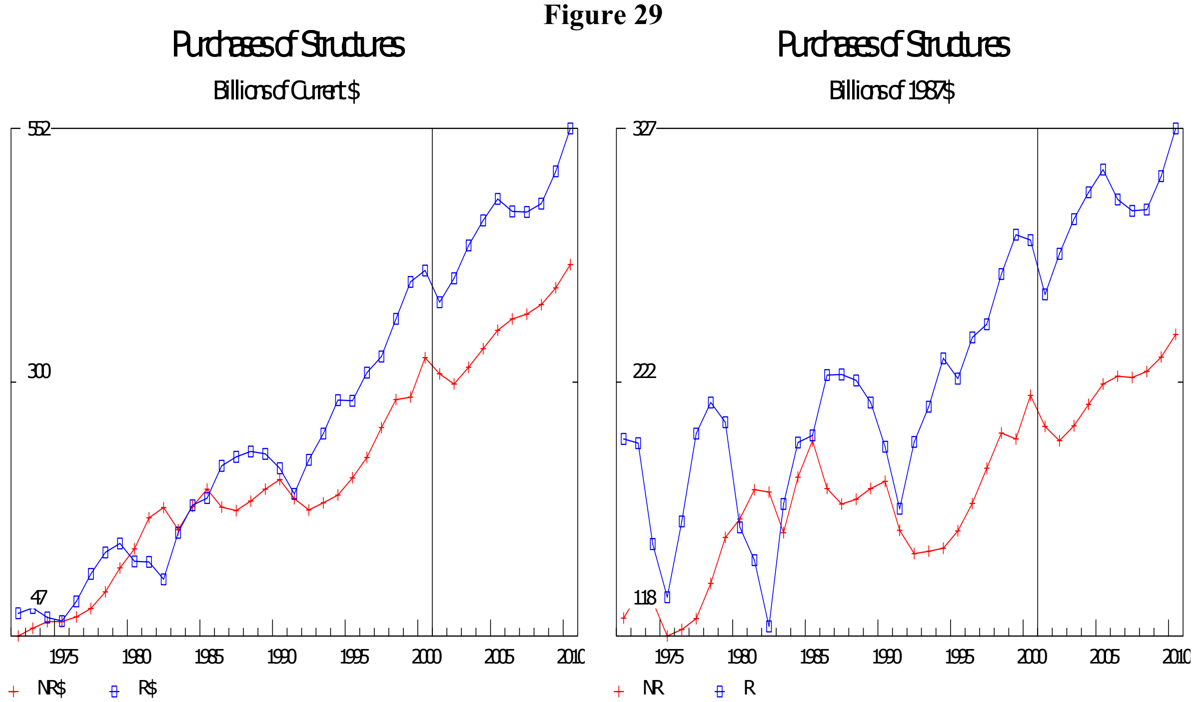
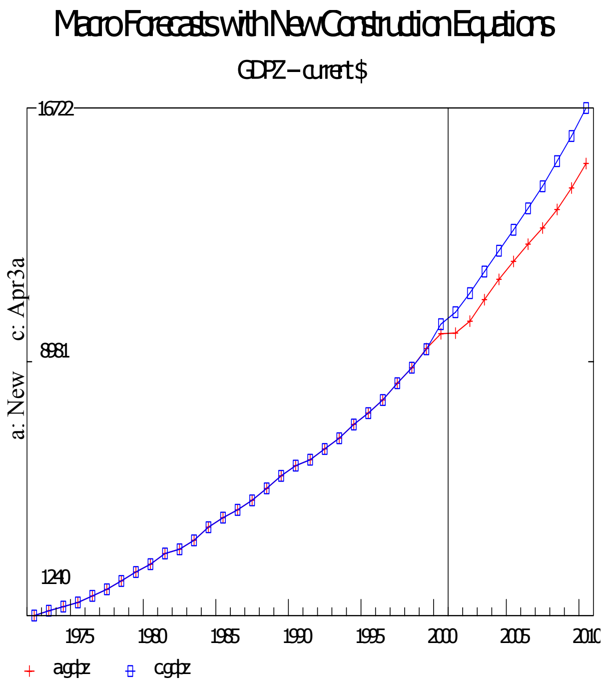


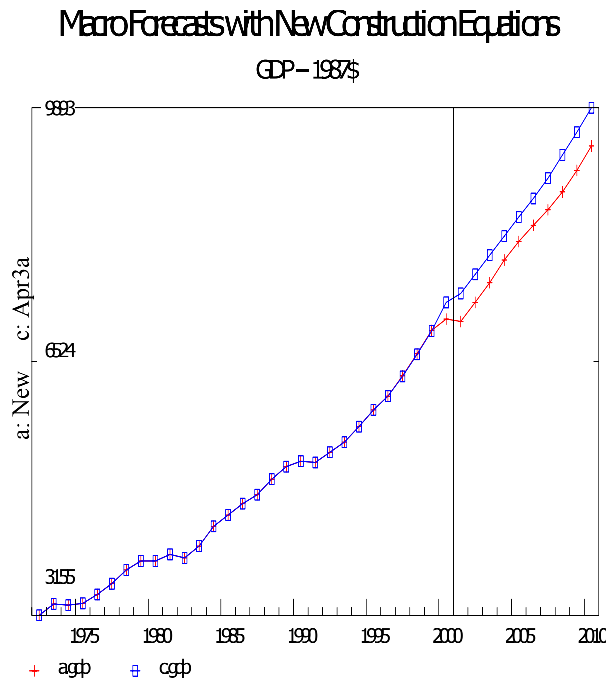
Figure 29 shows forecasts of nominal and real residential and nonresidential investment. The recent gap between residential and nonresidential investment is expected to remain approximately constant. Similar growth rates are expected for both categories.

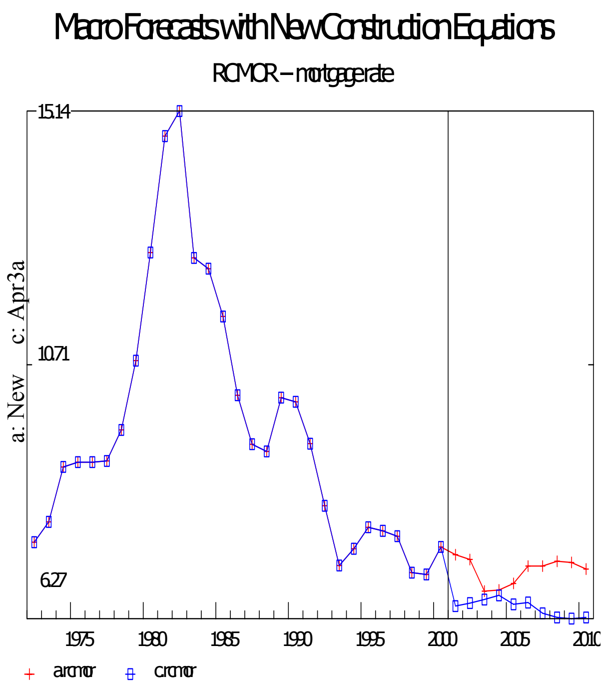
Figure 29

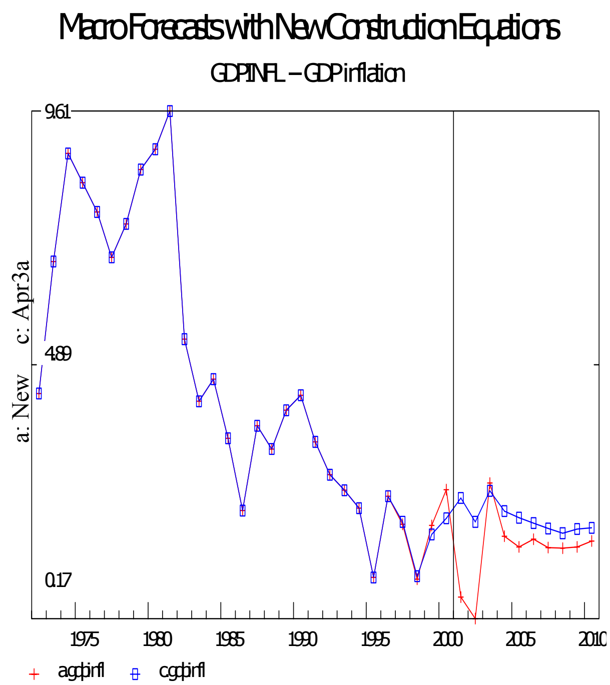


Forecasts of most major macroeconomic variables changed only slightly with the substitution of new construction equations. GDP, in real and nominal terms, grows at a rate similar to those in earlier forecasts, although the last points in the historic data and first points in the forecast are slightly lower. In the April forecasts, interest rates were controlled by fixes; the model alone determined interest rates in this run. Mortgage rates are somewhat higher without interest rate fixes, and inflation falls briefly before resuming a path similar to that in the earlier forecast.

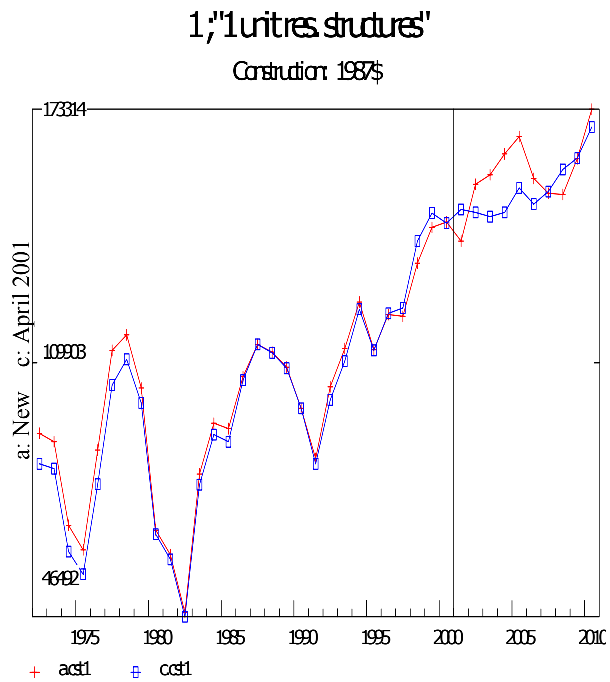

Macro Forecasts with New Construction Equations
GDPZ - current $
16722
8981
1240
a: New c: Apr3a
1975 1980 1985 1990 1995 2000 2005 2010
agdpz cgdpz

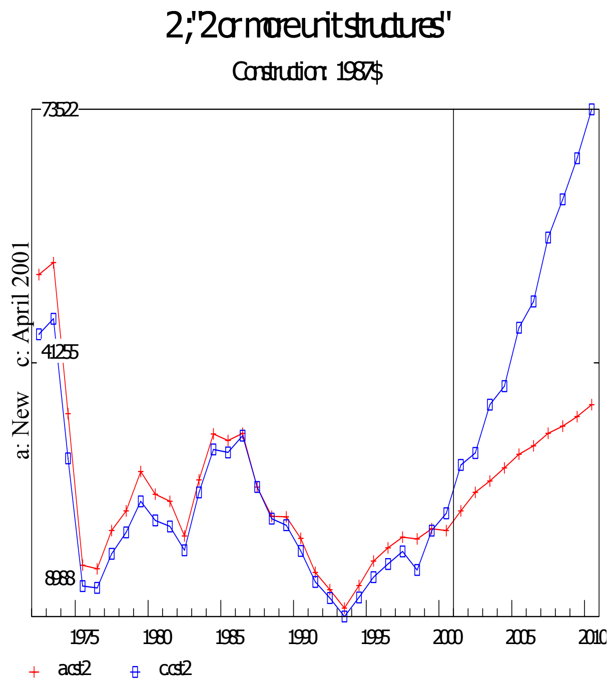

Macro Forecasts with New Construction Equations
GDP - 1987 $
9893
6524
3155
a: New c: Apr3a
1975 1980 1985 1990 1995 2000 2005 2010
agdp cgdp

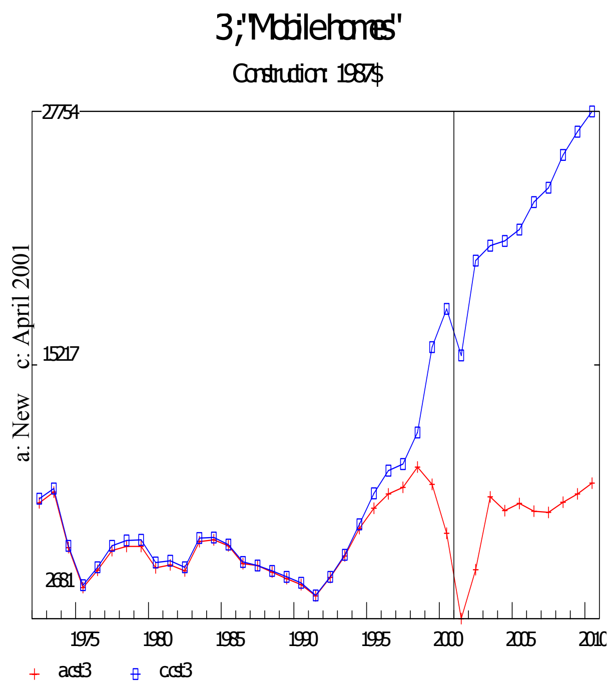

Macro Forecasts with New Construction Equations
RCMOR - mortgage rate
15.14
10.71
6.27
a: New c: Apr3a
1975 1980 1985 1990 1995 2000 2005 2010
armor crmor

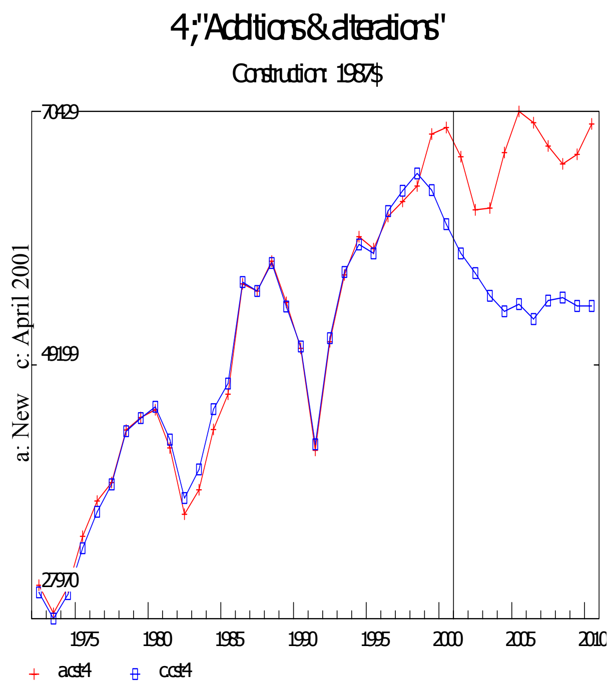

Macro Forecasts with New Construction Equations
GDPINFL - GDP inflation
9.61
4.89
0.17
a: New c: Apr3a
1975 1980 1985 1990 1995 2000 2005 2010
agdpinfl cgdpinfl

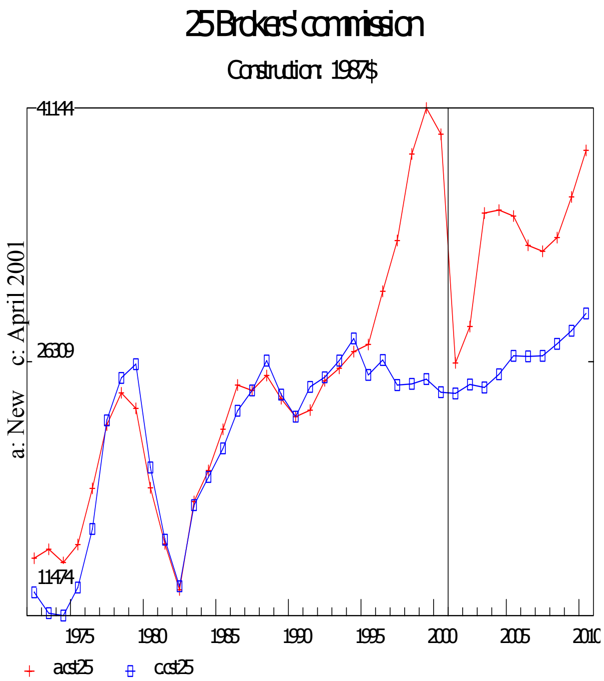
Changes in the construction data are very obvious for some series; once again, the primary differences are in the price series used to deflate construction. Also evident is the change in the forecast period for construction: actual construction data used in the April forecast ends in 1998, while data for the new forecast ends in 2000.

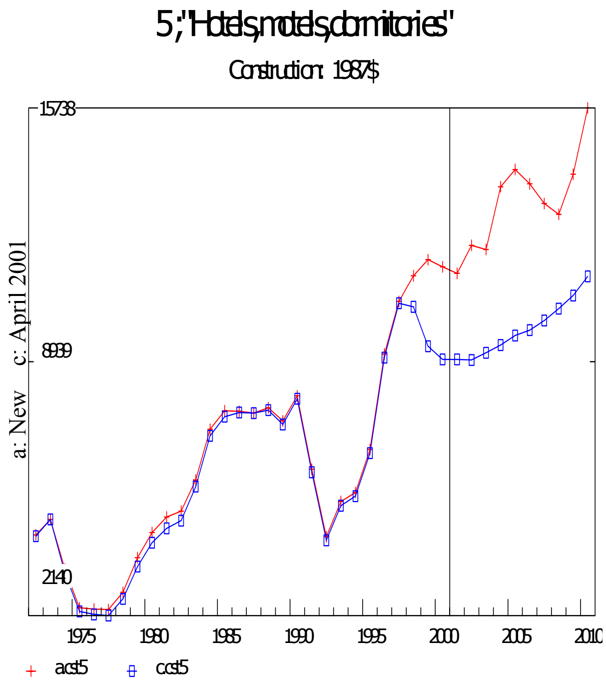


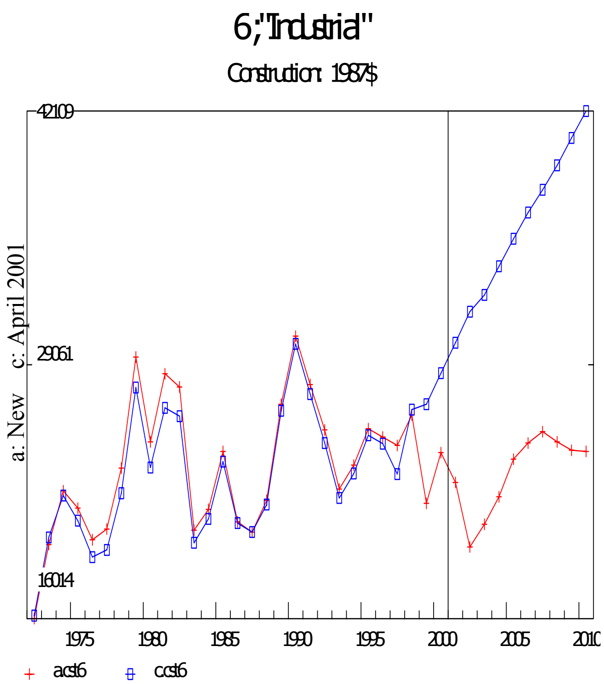


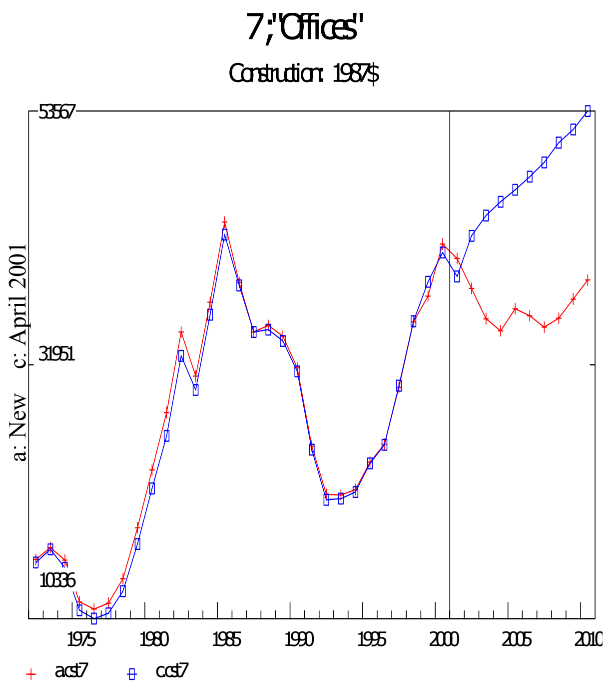


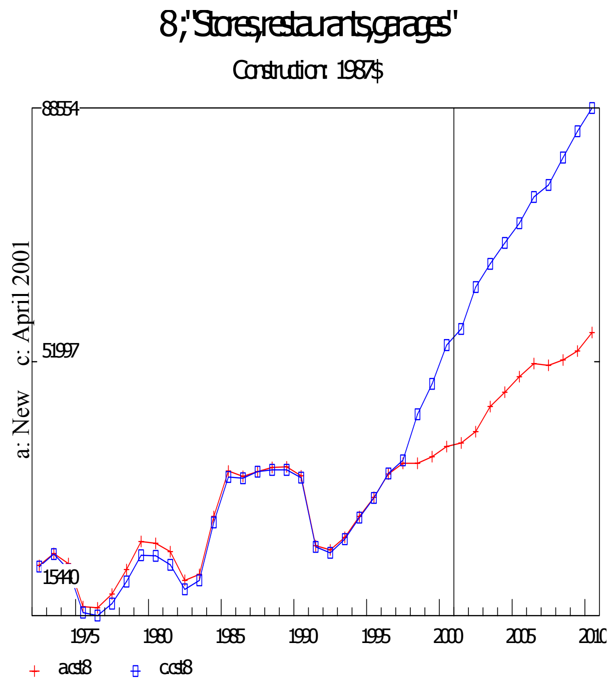


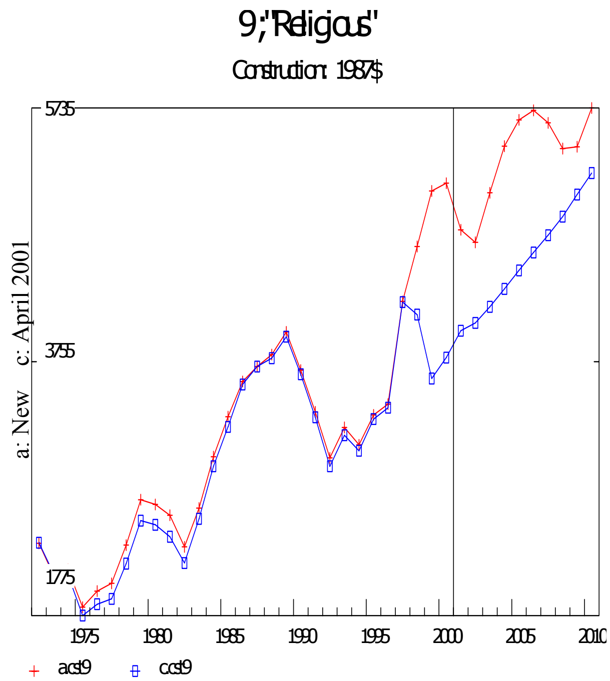

25 Brokers' commission
Construction: 1987$
41144
26309
11474
a: New c: April 2001
1975 1980 1985 1990 1995 2000 2005 2010
acst25 ccst25

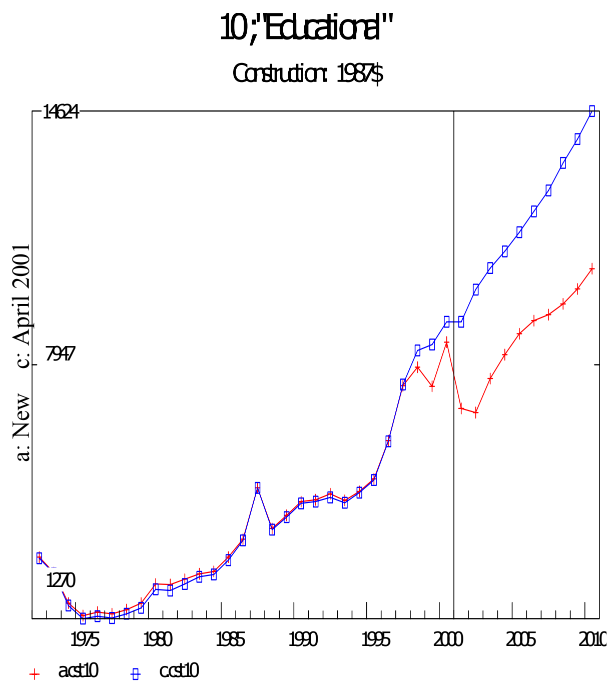

5;"Hotels,motels,dormitories"
Construction: 1987$
15738
8939
2140
a: New c: April 2001
1975 1980 1985 1990 1995 2000 2005 2010
acst5 ccst5

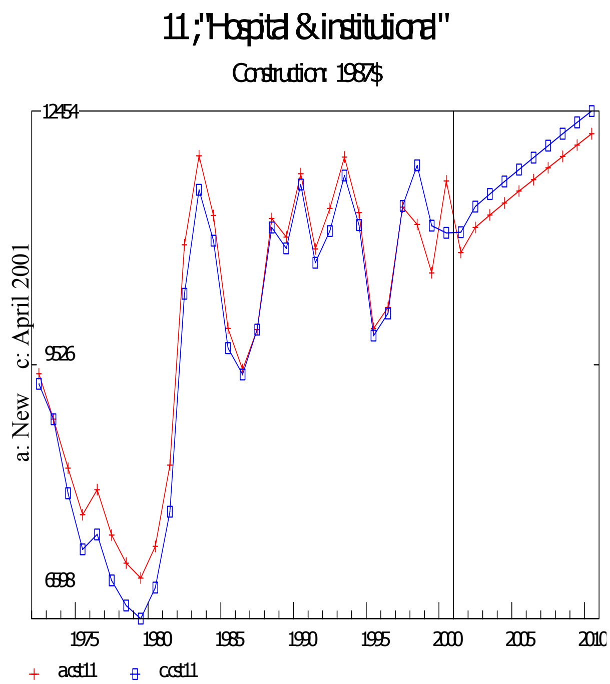

6;"Industrial"
Construction: 1987$
42109
29061
16014
a: New c: April 2001
1975 1980 1985 1990 1995 2000 2005 2010
acst6 ccst6

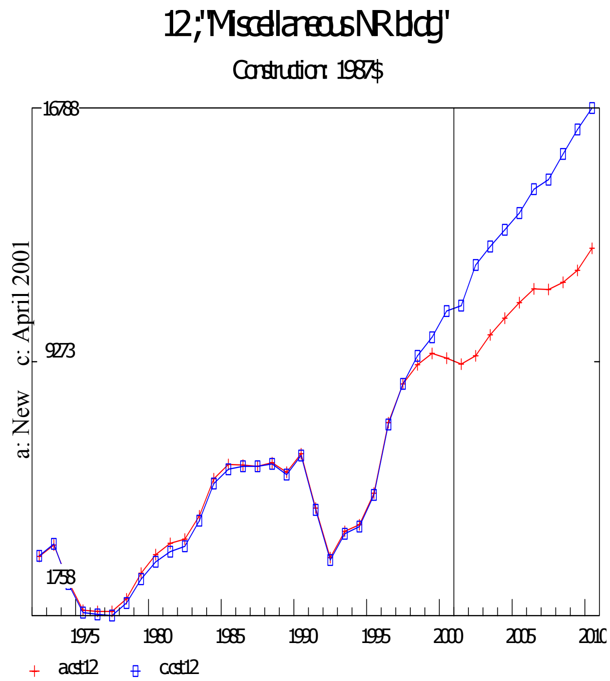

7;"Offices"
Construction: 1987$
53567
31951
10336
a: New c: April 2001
1975 1980 1985 1990 1995 2000 2005 2010
acst7 ccst7

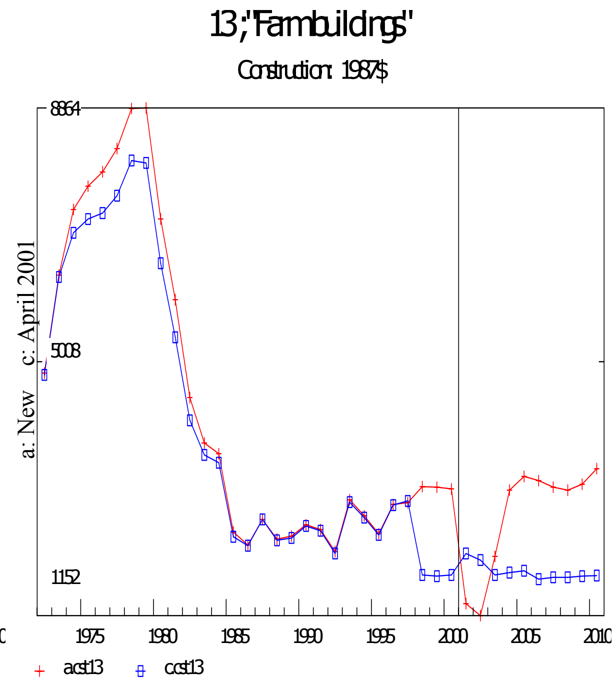

8;"Stores,restaurants,garages"
Construction: 1987$
88554
51997
15440
a: New c: April 2001
1975
1980
1985
1990
1995
2000
2005
2010
act8
cct8


9;"Religious"
Construction: 1987$
5735
3755
1775
a: New c: April 2001
1975
1980
1985
1990
1995
2000
2005
2010
act9
cct9

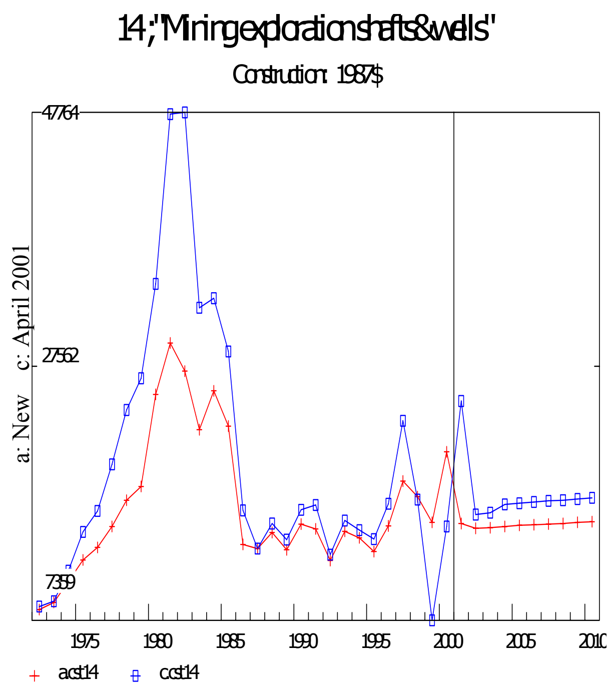

10;"Educational"
Construction: 1987$
14624
7947
1270
a: New c: April 2001
1975
1980
1985
1990
1995
2000
2005
2010
act10
cct10

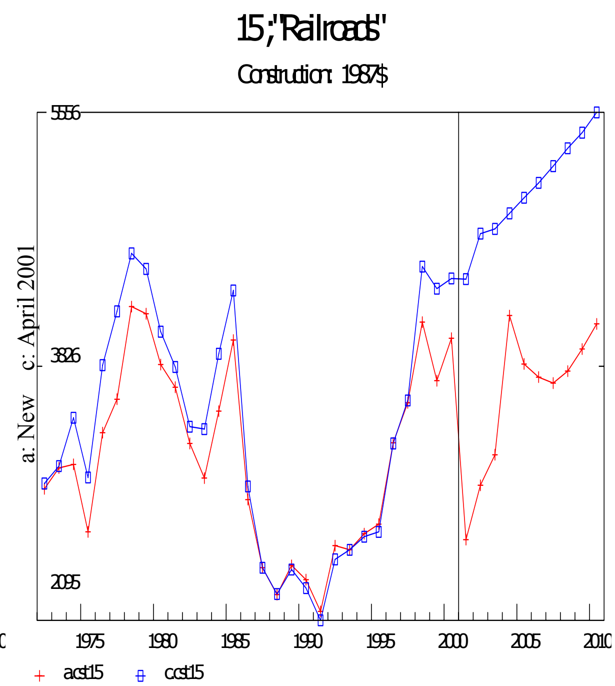

11;"Hospital & institutional"
Construction: 1987$
12454
9526
6598
a: New c: April 2001
1975
1980
1985
1990
1995
2000
2005
2010
act11
cct11

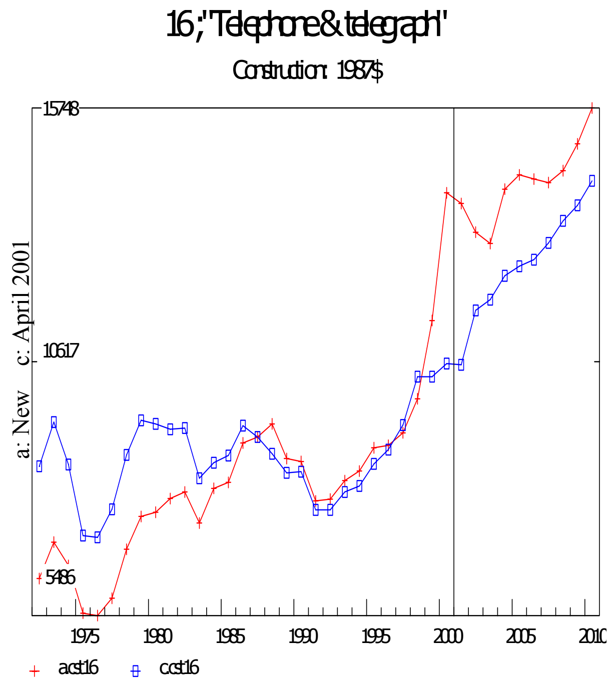


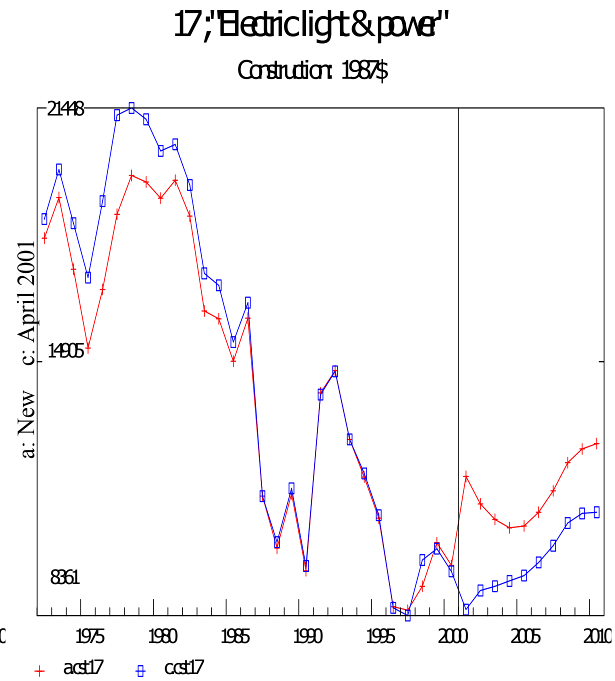


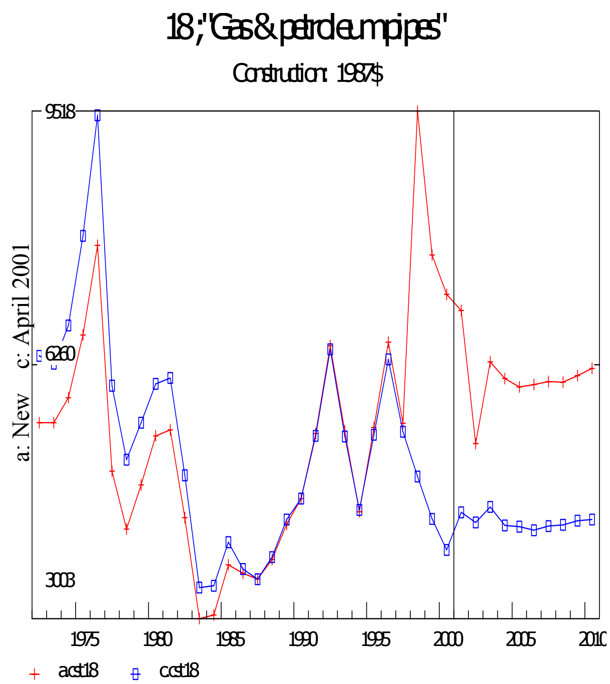
Investment in Sector 15, Railroads, is projected to fall dramatically in 2001 because of low expectations for GDP. The change in GDP from 2000 to 2001 thus is low, and the coefficient is positive on GDP changes in the Railroad model. Except for the single period, the forecast path looks reasonable. Similarly, rapidly changing oil prices cause a dramatic change in the path for Electric light and power. If the 2001 values are believed improbable, they can be altered by including fixes in the model. Such fixes are employed to modify implausible values or to incorporate information or expectations that are not built into the model.

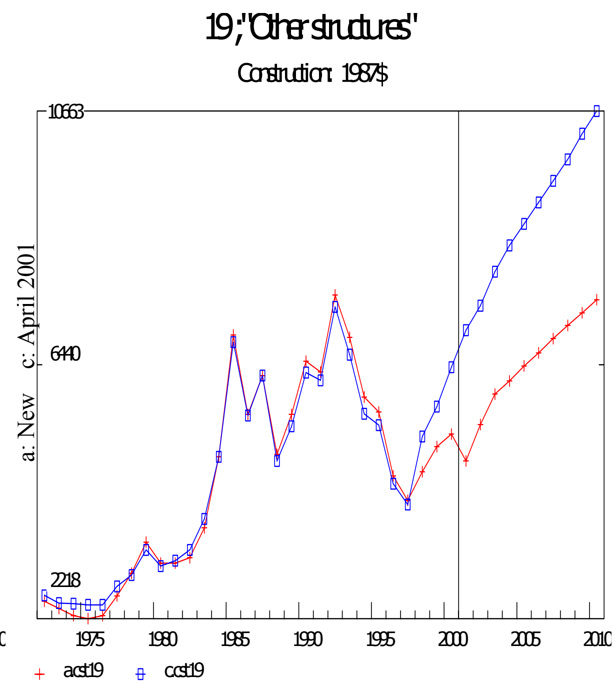












Conclusions and Further Research

New equations for investment in structures by type have been estimated with new series derived from NIPA data. The equations replace existing models in *IDLIFT*. The *IDLIFT* macroeconomic/ interindustry model has been evaluated using settings and assumptions very similar to those employed in a recent Inforum forecast, published in April, 2001. The new projections are compared those made earlier. Construction is projected to continue to contribute about seven percent of GDP. Given the assumptions that seemed appropriate in April, 2001, nonresidential and residential construction are expected to resume robust growth after slumping in 2001 and 2002. Following years of near equality, investment in residential structures is projected to maintain its recent dominance of nonresidential investment. Although the introduction of new investment equations alters dramatically the forecasts of certain investment categories, projections of real GDP are changed little. Among residential types, all but multi-family units are expected to fall early in this decade. By the end of the decade, real growth projections are positive for all residential sectors relative to levels in 2001. Investment in most nonresidential types also is expected to fall in the next few years and then to recover. These construction forecasts are made without intervention by fixes. A complete forecast and update of *IDLIFT* may impose some fixes to alter unlikely paths or to incorporate outside knowledge. Hence, while these forecasts demonstrate properties of the equations, the November, 2001 Inforum forecast provides the first formal projections employing the models developed here.

Future research will seek to unify the models of investment in structures with investment in other factors, including equipment and labor. Such efforts will focus on nonresidential investment by firms. Hence, the residential models discussed here still may be needed. Alternatively, investment in residential structures may be linked to consumption.

The cause of falling investment to output ratios still are undiscovered. Answers likely may be found in the data and equations of *IDLIFT*, but further work is needed to yield convincing explanations. Examination of other output ratios or comparisons of investment to other variables may provide clues. Both nonresidential construction to output and residential construction to output ratios began to fall at approximately the same time and have fallen by similar amounts. This suggests that another component of final demand increased its share in the early 1980's. Perhaps firms and consumers changed their behavior and thus require fewer buildings, or perhaps quality has improved so that buildings last longer. These are possible but are not convincing. More likely, production and consumption of high tech and other high value goods increased during the past two decades. Production of computers, for example, may require less factory space than would production of steel of equal value. Similarly, consumers may have increased consumption of small, expensive high tech goods relative to consumption of lower priced bulky products like furniture. Other possibilities exist as well, suggesting much work remains in the quest to model investment in structures.

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