Interest Rates, Exchange Rates, and the Federal Budget Deficit in INFORUM'S LIFT Model

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In this paper we review changes that have been made to the LIFT model in support of Task 4 of contract 500-93-0007. Task 4 asked us to review the literature on the effects of the federal deficit on the economy, especially through the deficit's effects on interest rates and exchange rates. In addition, we re-examined the role of interest rates in the LIFT model, and made changes where appropriate. In some cases, we added interest rate terms to final demand equations that previously did not allow for interest rate effects. Finally, we re-estimated some of the key macroeconomic relationships in the model, as part of a review of the macroeconomic properties of the LIFT model.

Significant changes have been made in several areas.

- Interest rate equations
- Personal saving rate equation
- Equation for Per hour compensation in manufacturing.

In addition to changing existing equations, an exchange rate scaler function has been added to the model that can be used when LIFT is running independently of its country partner models. Finally, equations for consumer spending have been revised to incorporate interest rate effects and new equations have been estimated for construction. The work on consumer spending was done in support of this contract, however, the construction estimations were done as a part of a general refurbishing of the LIFT model. The new construction equations are described in Monaco (1993).

Interest Rate Equations

Our recent work on interest rate equations has focused on two areas: structural change in financial markets and whether the Federal deficit could be meaningfully used to help explain interest rate movements. Rapid structural change in financial markets was the norm in the early 1980s. A major step was taken when Regulation Q, which put ceilings on interest rates banks and savings and loans could pay on savings accounts, was phased out. As explicit, market-determined interest rates began to be paid on various components of the money supply, the relationship between the monetary aggregates and interest rates began to change through the early 1980s.

At about the same time that the move toward deregulation began in earnest -- late in 1979 -- the Federal Reserve changed its monetary policy operating procedure. The shift in operating procedure -- from trying to maintain a federal funds rate target to monitoring monetary aggregates -- resulted in a sharp spike in interest rates in 1980 and 1981. Coincident with its change in operating procedure, the Federal Reserve began to pursue a tight money policy, and began establishing "credibility" as an inflation fighter. These developments also likely caused a change in the relationship between the monetary aggregates (M1, M2, etc) and interest rates. For example, prior to 1979, an unusually large increase in the money supply was likely to be associated with falling interest rates via a "liquidity" effect. After the policy change, an unusually large increase in the money supply was very likely to be accompanied by rising interest rates, as market participants viewed the increase as inflationary and likely to bring about tighter money.

A monthly or quarterly model with more observations could more precisely model the effects of these changes. However, LIFT is an annual, long-term forecasting model and simulation tool. As such, we want to incorporate variables that show fundamental changes in real activity, monetary activity, inflation, and possibly incorporate a role for the Federal deficit. When we estimated our equations, we searched for structural breaks in the relationship centering around 1980. The key interest rate modeled is the three month Treasury bill rate. Other interest rates are modeled using either this variable, or the rate on 10 year Treasury notes, which is a direct function of the 3-month rate. Estimation results for the interest rate equations are shown in Table 1.

The equation for the 3-month bill rate shows that there is a significant structural break that changed the inflation effect and the base money growth effect. We are using the St. Louis Federal Reserve Bank's adjusted monetary base as our base money measure. The St. Louis base includes an adjustment for changes in legal reserve requirements, while the "source" base -- bank reserves plus currency in the hands of the public -- does not. The use of the base money growth variable is especially effective in predicting interest rate behavior over the last couple of years. From late 1990 through the present, the monetary base has been growing very quickly, while M2 and other higher aggregates have been growing very slowly. Equations based on M2 tend to miss the current experience -- low M2 growth combined with low interest rates -- quite badly. Equations using some base concept tend to do somewhat better. To capture the effects of changing levels of economic activity, we chose the unemployment rate. A 1 percentage point increase in the unemployment rate reduces this interest rate by nearly 90 basis points.

The last variable entering the 3-month rate equation is the sum of nominal gross private domestic investment and the Federal deficit relative to nominal GNP. This variable is intended to capture financial market demand pressures. Higher values of this ratio indicate a higher demand for financial capital. The equation suggests that a 1 percentage point increase in this ratio raises the 3-month bill rate by about 44 basis points. Note that while the equation suggests that, all else equal, an increase in the Federal deficit raises interest rates, it does not suggest every increase in the deficit increases interest rates. For example, if the deficit rises due to a recession, the GNP share of investment is likely to be lower, leading to a smaller change in the pressure ratio than the deficit share alone would indicate.

The LIFT equations are generally consistent with recent work done by Arora and Dua [1993], who review previous studies linking the Federal deficit with interest rates. In general these authors find several recent studies showing a statistically positive link between Federal deficits and interest rates.

Other interest rate equations displayed in Table 1 are generally self-explanatory. The equation for the Aaa bond rate, however, uses the ratio of internally generated funds (profits and depreciation relative to GNP) to explain the difference between its yield and the 10-year note rate.

Here is a list of interest rates available in LIFT:

RTB	Yield on 3-month Treasury bills
RTB10Y	Yield on 10-year Treasury notes
RAAA	Yield on Aaa-rated corporate bonds (Moody's)
RCP	Rate on 3-6 month commercial paper
RCMOR	Rate on conventional mortgages

Monetary Aggregates in LIFT

As part of the re-estimation of the interest rate equations, we revised the LIFT treatment of the monetary aggregates. In the previous version of LIFT, M2 was exogenous. In the re-estimation, the equation for the yield on 3-month Treasury bills was found to be linked more directly to movements in the real monetary base. Users of LIFT now have several choices for setting monetary policy. In general, users must fix two of the three following concepts: Nominal monetary base (Lift variable MBASE), money multiplier (MMULT), M2 (M2). The variables are related through the following equation:

M2 = MBASE * MMULT.

Values for the third variable are always determined through the two variables that are fixed and the equation above. For example, if M2 and the monetary base are fixed, values for the money multiplier will be calculated. Fixing the monetary base and the money multiplier will cause LIFT to calculate M2. It is useful to remember that the monetary base enters the interest rate equations and that M2 appears in the manufacturing wage equation. The money multiplier does not enter any other equation. For most purposes, we suggest the model user set either base money growth in nominal terms or M2 growth in nominal terms and hold the money multiplier constant at its last known value. This combination of fixes will ensure that M2 growth matches base money growth, which appears to be the case over extended periods of time. Over the 20 years from 1973 through 1992, the adjusted monetary base (published by the St. Louis Federal Reserve Bank) grew 7.8 percent annually, exactly matching the 7.8 percent annual growth in M2. We anticipate doing further research into forecasting MMULT.

A final method for specifying M2 growth is to make the ratio of M2 to nominal GNP (LIFT variable M2OGNP) exogenous. This makes M2 velocity exogenous and makes M2 endogenous to the model. However, because M2, MBASE, and MMULT are linked through the above equation, the user can only fix either MBASE or MMULT when M2 velocity is exogenized.

In LIFT, the inflation expectations variable (USPEXP) can be altered by the user. As a default, it is a three-year moving average of inflation measured by the GNP deflator. For some simulations, like a temporary surge in oil prices, users could smooth the path of USPEXP to allow for the possibility that longer term inflation expectations were unaffected by the commodity price shock.

TABLE 1

Interest Rate Equations

3-month Treasury Bill Rate

SEE = 0.67	RSQ = 0.9288	RHO = 0.17	Obser = 29 from 1964.000
SEE+1 = 0.67	RBSQ = 0.9094	DW = 1.66	DoFree = 22 to 1992.000
MAPE = 9.64			

Variable name	Reg-Coef	Mexval	t-value	Elas	NorRes	Mean
0 rtb	- - -	- - -	- - -	- - -	- - -	6.78
1 intercept	0.74744	0.5	0.476	0.11	14.05	1.00
2 Pre 1980 smooth infl	0.48053	22.6	3.329	0.20	12.92	2.82
3 Post 1979 smooth infl	1.02727	59.7	5.840	0.37	3.84	2.42
4 Pre 1980 Base growth	-0.49080	21.9	-3.268	-0.06	3.76	0.90
5 Post 79 Base growth	-0.26437	12.9	-2.461	-0.04	2.55	1.14
6 Unemp rate	-0.87117	40.8	-4.646	-0.78	1.85	6.10
7 (GPDI+Fed Def)/GNP	0.43962	35.9	4.315	1.22	1.00	18.75

10 Year Treasury Note Rate

SEE = 0.65	RSQ = 0.9286	RHO = 0.33	Obser = 29 from 1964.000
SEE+1 = 0.62	RBSQ = 0.9168	DW = 1.34	DoFree = 24 to 1992.000
MAPE = 5.97			

Variable name	Reg-Coef	Mexval	t-value	Elas	NorRes	Mean
0 rtb10y	- - -	- - -	- - -	- - -	- - -	8.13
1 intercept	-1.33153	2.0	-0.983	-0.16	246.09	1.00
2 rtb	0.31933	18.4	3.116	0.27	3.47	6.78
3 Pre 1980 smooth infl	0.27978	29.4	4.033	0.10	3.30	2.82
4 Post 1979 smooth infl	0.67635	66.7	6.549	0.20	1.58	2.42
5 (GPDI+Fed Def)/GNP	0.25948	25.8	3.747	0.60	1.00	18.75

The coefficients on rtb and Post 1979 smooth inflation were constrained to sum to approximately one in order to assure full inflation pass-through.

Commercial Paper Rate

SEE = 0.35	RSQ = 0.9825	RHO = 0.23	Obser = 29 from 1964.000
SEE+1 = 0.34	RBSQ = 0.9818	DW = 1.55	DoFree = 27 to 1992.000
MAPE = 3.65			

Variable name	Reg-Coef	Mexval	t-value	Elas	NorRes	Mean
0 rcp	- - -	- - -	- - -	- - -	- - -	7.51
1 intercept	0.46800	10.4	2.426	0.06	57.09	1.00
2 rtb	1.03896	655.6	38.916	0.94	1.00	6.78

Mortgage Rate

SEE = 0.43	RSQ = 0.9641	RHO = -0.05	Obser = 29 from 1964.000
SEE+1 = 0.42	RBSQ = 0.9628	DW = 2.11	DoFree = 27 to 1992.000
MAPE = 3.07			

Variable name	Reg-Coef	Mexval	t-value	Elas	NorRes	Mean
0 rcmor	- - -	- - -	- - -	- - -	- - -	9.13
1 intercept	1.82768	59.4	6.451	0.20	27.87	1.00
2 rtb10y	0.89892	428.0	26.937	0.80	1.00	8.13

Aaa Bond Rate

SEE = 0.24	RSQ = 0.9907	RHO = 0.39	Obser = 29 from 1964.000
SEE+1 = 0.22	RBSQ = 0.9899	DW = 1.21	DoFree = 26 to 1992.000
MAPE = 2.51			

Variable name	Reg-Coef	Mexval	t-value	Elas	NorRes	Mean
0 raaa	- - -	- - -	- - -	- - -	- - -	8.78
1 intercept	4.99880	37.1	4.781	0.57	106.98	1.00
2 rtb10y	0.96502	792.5	45.221	0.89	1.69	8.13
3 (Profits+Depre)/GNP	-0.22989	30.1	-4.244	-0.46	1.00	17.67

Savings Rate Equation

The savings rate equation plays a key role in the model. Although the real consumer spending equations determine the amount spent on each commodity, the total volume of consumer spending is determined from a forecast of disposable income and the savings rate. In effect, the savings rate equation operates much like an aggregate consumption function found in most other models. The savings rate in LIFT (SAVRAT) is defined as personal savings divided by disposable income less personal transfer payments to foreigners. LIFT uses the following equation to determine the spending rate (SPENDR):

SPENDR = 1-(SAVZ+YIC+TRPFRN)/DIZ

where

SPENDR	=	personal consumer spending relative to disposable income
SAVZ	=	personal savings
YIC	=	interest paid by consumers to business
TRPFRN	=	personal transfer payments to foreigners
DIZ	=	disposable income

The spending rate is then applied to disposable income to derive the total amount of consumer spending.

Several years of simulation experience have suggested some properties that the savings rate equation must possess if it is to work well with LIFT's sectoral equations. We have found, for example, that we need the saving rate to fall as the unemployment rate rises in order to make the model stable. In our recent work, we have added a nominal interest rate to the savings rate equation, suggesting that as nominal interest rates rise, the volume of consumer spending shrinks. In our formulation, nominal interest rates, rather than real interest rates, have been added to the equation. Nominal interest rates can play a large role in determining consumer spending (or forced saving) if consumers are faced with liquidity constraints, i.e. they cannot meet the loan requirements at high interest rates because of the use of nominal loan-to-value ratios in consumer lending. For additional information, see Wilcox (1989).

In this particular estimation, the savings rate is assumed to decline point for point with each increase in the ratio of Social Security contributions to personal income. Further, the savings rate is assumed to decline 0.5 percentage points for each percentage point increase in the unemployment rate. After adjusting the dependent variable for these constraints, the estimated savings rate equation is:

```
 Saving Rate Constrained:  Social Security share coef = -1,
 Unemployment rate coef = -0.5
SEE   =       1.42 RSQ   = 0.4866 RHO =   0.59 Obser  =   33 from 1960.000
SEE+1 =       1.18 RBSQ  = 0.4524 DW  =   0.81 DoFree =   30 to   1992.000
MAPE  =       8.71
  Variable name           Reg-Coef  Mexval t-value  Elas   NorRes     Mean
0 savrat1               - - - - - - - - - - - - - - - - - - - - -     13.95
1 intercept               11.01579   212.4  16.209   0.79    1.95      1.00
2 3 month T-bill rate      0.49438    36.8   5.111   0.22    1.06      6.30
3 dum86                   -0.85377     3.0  -1.348  -0.01    1.00      0.21
```

The dummy variable catches a downward shift in the savings rate that appeared to begin in 1986.

Users can over-ride the savings rate equation by specifying values for SAVRAT in the MACROFIX.DAT file. However, because YIC and TRPFRN will be endogenous, the spending rate may differ somewhat from what the user wants. Users can specify values for SPENDR directly if they want to control the total amount of consumer spending more closely. LIFT will automatically recalculate SAVRAT to be consistent with the user-specified spending rate.

The Exchange Rate Scaler Function

LIFT is the U.S. model in an international system of country models. When all of the country models are run together, exchange rates are set exogenously and countries are linked through trade flows (exports and imports) and sectoral prices. In each country model, including LIFT, exports for each commodity respond to foreign demands and the price of competing exporters relative to the domestic price. Imports for each commodity respond to domestic demand and the price of imports relative to the domestic price. Usually the international system is iterated several times, and exchange rates are examined and changed when the relative country results appear to warrant some exchange rate movement. For example, a simulation that showed a large and ever-widening U.S. merchandise trade deficit with exogenous exchange rates would likely cause us to lower the value of the dollar before subsequent iterations of the system.

LIFT is often simulated by itself, however, using an exogenous set of foreign demands and an exogenous set of foreign price levels. Those exogenous assumptions are usually consistent with the most recent instance that LIFT was run as part of the international system. When run alone, LIFT simulations that raise or lower the overall U.S. price level relative to exogenous foreign prices have strong trade effects because inflation changes relative foreign-to-domestic prices. For example, a simulation that raised the aggregate U.S. price index one percent above the most recent instance that LIFT was run as part of the international system would cause U.S. prices to be, on average, one percent higher than the exogenously-specified foreign prices. The change in relative domestic-to-foreign prices for each commodity would increase imports and reduce exports.

Economic theory (purchasing power parity), however, suggests that the exchange rate would adjust to the change in the U.S. price level. The higher overall U.S. price index would then be offset by a decline in the value of the dollar, mitigating the change in real trade flows. It is important to note that not all of the volume effect would disappear, since some U.S. prices would rise more quickly than others. For those commodities, there would continue to be a tendency for imports to increase exports to decline.

Similarly, simulations that result in significantly higher or lower real interest rates in the U.S. should have some impact on foreign trade. High real interest rates in the early 1980s are largely blamed for driving up the value of the dollar, and causing exports to drop and imports to rise. This link was not in previous versions of LIFT.

To deal with these concerns, we devised an exchange rate scaler function. Our function follows simple macroeconomic theory that suggests when real interest rates rise in the U.S. relative to other countries, the value of the dollar should rise too, reducing exports and encouraging imports. We estimated this equation using data from the IMF to calculate nominal long-term bond rates, inflation and real long-term bond rates six key developed-country trading partners. To aggregate the individual country data we used weights from the Federal Reserve Board's trade-weighted exchange rate (see below). Other weighting schemes were tried, including using the IMF (MERM) weights, and a 50-50 weighting scheme using only data for Japan and Germany. The best results were obtained using the Federal Reserve index weights. The weights used are:

Federal Reserve weights for Big 6 (percent)

Germany	--	20.8	Japan	--	13.6
France	--	13.1	UK	--	11.9
Canada	--	9.1	Italy	--	9.0

Big 6 countries account for 77.5 percent of FRB exchange rate.

The equation for the real exchange rate is:

```
                    Real Federal Reserve Exchange Rate
SEE   =      10.35 RSQ   = 0.5853 RHO =   0.54 Obser  =   17 from 1974.000
SEE+1 =       8.81 RBSQ  = 0.5577 DW  =   0.91 DoFree =   15 to   1990.000
MAPE  =       8.21
  Variable name           Reg-Coef  Mexval t-value  Elas   NorRes     Mean
0 Real FRB Exch. Rate   - - - - - - - - - - - - - - - - - - - - -    106.76
1 intercept              105.56756   920.1  39.317  0.99    2.41      1.00
2 Real rate (US-Foreign)   7.81482    55.3   4.601  0.01    1.00      0.15
```

The equation suggests that if the real interest rate differential rises by 1 percentage point, the real exchange rate rises by about 7 percent. To calculate the nominal exchange rate, we use exogenous forecasts of the overall foreign price index and the calculated U.S. aggregate price index and the forecast of the real exchange rate. We simply use the equation:

Nominal exchange rate = Real Federal Reserve Index * Foreign price index / U.S. price index.

In LIFT, the exchange rate scaler is the inverse of the nominal FRB exchange rate. In simulations, a falling scaler means a rising value of the dollar.

To complete the exchange rate scaler scheme, we need an equation to forecast nominal or real interest rates abroad, based on something that LIFT already forecasts. We chose to estimate a real interest rate equation, based on the U.S. real interest rate.

```
                     Foreign Real Interest Rates (FRB weights)
SEE   =       0.97 RSQ   = 0.6176 RHO =   0.68 Obser  =   17 from 1974.000
SEE+1 =       0.74 RBSQ  = 0.5921 DW  =   0.65 DoFree =   15 to   1990.000
MAPE  =     146.43
  Variable name           Reg-Coef  Mexval t-value  Elas   NorRes     Mean
0 Foreign real rate     - - - - - - - - - - - - - - - - - - - - -      3.09
1 intercept                1.46904    35.6   3.548  0.48    2.61      1.00
2 US real rate             0.49974    61.7   4.922  0.52    1.00      3.24
```

The equation suggests that a one percentage point increase in U.S. real rates is associated with about a 50 basis point increase in foreign real interest rates. Thus, all else equal, a 1 percentage point increase in real U.S. interest rates leads to a 50 basis point increase in real foreign interest rates and about a 3.5 percent rise in the real value of the dollar. When running simulations, foreign inflation is exogenous to LIFT, and is generally set at the average rate calculated using FRB weights and LIFT international partner country forecasts where available.

The above mechanism allows the value of the dollar to appreciate when U.S. real interest rates increase and allows the dollar to depreciate when the U.S. price level rises relative to foreign prices. There are several ways that users can take control of the exchange rate scaler.

- o The exchange rate scaler can be set exogenously (LIFT variable EXSCL). The full range of fixes are available for modifying EXSCL or setting it exogenously. Fixes are applied in the MACROFIX.DAT file.

- o Foreign real interest rates can be modified or set exogenously in the MACROFIX.DAT file. The LIFT variable name is FORRR. Setting FORRR to be constant overrides the equation presented above and will increase the responsiveness of the exchange rate scaler to changes in U.S. real interest rates. Note that this variable represents the "average" real interest rate across six trading partners, holding constant the weights shown above.

- o Exogenous foreign inflation can be modified. The LIFT variable to modify is FORPI (foreign price index), also in the MACROFIX.DAT file. Note that this variable represents the "average" price level across six trading partners, holding constant the weights shown above.

Deciding whether to let the exchange rate scaler be endogenously determined by the function shown above, or to set it exogenously at unity (or follow another path) is dependent on what the user thinks is the mostly likely scenario for foreign reactions to the simulated change in the U.S. economy. In most cases, the exchange rate scaler should be endogenous (fixes should be taken off) in those simulations that are likely to affect either the U.S. price level or real interest rates. Since most simulations will have effects on these two variables, the exchange rate scaler function should be used routinely, and using a fixed exchange rate scaler path should be justified by appeal to special circumstances.

The Manufacturing Wage Equation

The manufacturing wage equation -- or more precisely, the equation for labor compensation per hour in manufacturing -- is the single most important determinant of the inflation rate in LIFT. Labor compensation is by far the largest single component of value-added. The manufacturing wage equation sets the overall wage trend because sectoral wage equations are estimated relative to either the manufacturing wage or the non-manufacturing wage -- which depends strongly and directly on the manufacturing wage. In order to help ensure the property that increases in the money supply strongly affect the rate of inflation, we have incorporated "excess" money growth into the wage equation, where the excess is defined as the rate of growth over and above real GNP growth. This effect is smoothed and distributed over 4 years. We have also imposed the notion that longer-term productivity increases are fully incorporated in wages, by making wage growth rise 1 for 1 with a 3-year average of productivity growth. After imposing these two constraints, we estimated the remaining wage growth as a function of labor market tightness and a simple variable to capture price shocks that might occur in agriculture and crude oil markets. These two sectors account for most of the "supply shocks" that have occurred over the last 30 years. The estimated equation is shown below.

```
                 Manufacturing Wage with Commodity Prices
SEE   =       1.70 RSQ   = 0.6752 RHO =   0.47 Obser  =   23 from 1970.000
SEE+1 =       1.53 RBSQ  = 0.6427 DW  =   1.06 DoFree =   20 to   1992.000
MAPE  =     138.36
  Variable name          Reg-Coef  Mexval t-value  Elas   NorRes     Mean
0 gw1                  - - - - - - - - - - - - - - - - - - - - -    -0.25
1 supply                  0.03882     4.2   1.313  -0.31    2.43      1.99
2 supply[1]               0.14245    47.3   4.835  -1.31    1.20      2.26
3 tight[1]               33.96295     9.5   2.000   0.62    1.00     -0.00
```

In the above equation:

Tight is the first difference in the 2-year moving average of the inverse of the unemployment rate.

Supply is the average of the real price growth for LIFT sectors 1 and 6 (prices of agriculture and crude petroleum).

GW1 is the growth in labor compensation per hour in manufacturing minus the sum of smoothed excess money growth and smoothed productivity growth.

Consumer Spending Equations

To complement our work on the savings rate, we have re-estimated our system of consumer spending equations to incorporate interest rates where they were thought to be appropriate. In general, interest rate variables were included in the equations explaining purchases of durable goods. However, interest rates were found to be helpful in explaining spending on the following categories (approximate sensitivities to a 1 percentage point increase in interest rates in parentheses):

- New car purchases (-3.5 percent)
- Used car purchases (-4.1 percent)
- Truck purchases (-0.3 percent)

In addition to spending categories that are directly affected by interest rates, several PCE categories are now dependent on residential building activity, which is sensitive to general credit conditions. These sectors, and their sensitivities to a $1 (constant 1977$) increase in residential building and alterations are:

- Furniture and mattresses ($0.034)
- Kitchen and other household durables ($0.046)

These sensitivities suggest that a $1 billion (constant 77$) increase in residential building generates a $34 million increase in spending on furniture and fixtures and a $46 million increase in spending on household appliances.

It is useful to remember that the effect of higher levels of spending on residential construction, and also interest rates, do not affect the total amount of spending on consumer goods through these channels. Rather, these changes affect the distribution of consumer spending, and will have effects on the mix of employment and output in LIFT. The total amount of consumer spending in LIFT is sensitive to interest rates, but the sensitivity is due to the interest effect on savings, not through the interest effect on particular categories of consumer spending.

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