Research Memorandum

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Subj: Distribution of quarterly values of GDP/GDI across months within the quarter

Background

For many purposes it is useful to have estimates of the monthly values of GDP and GDI. The BEA constructs quarterly values of GDP/GDI (both real and nominal), but not monthly values. However, several of the components of GDP/GDI are available monthly (for example, personal consumption expenditures (a GDP component) and compensation of employees (a GDI component)), and even when a monthly component is not available, there is often another variable or set of related variables that is available monthly (for example, total private residential construction, a monthly series published by the Census Bureau, is related to the residential investment component of GDP).

In this memorandum we describe how we have used monthly series to construct monthly estimates of GDP and GDI.[1]

Notation and general method

Our general method is to carry out distribution for components of nominal GDP and GDI. The sum of the monthly estimates of the nominal components is the monthly estimate of nominal GDP and GDI. Monthly estimates of the GDP deflator are also computed, and these estimates are used to deflate the monthly nominal values of GDP/GDI to produce monthly estimates of real GDP/GDI.

Distribution of the quarterly values of a specific component of GDP/GDI is constructed as follows. Let upper case variables denote the quarterly series/time index (Q_T denotes the quarterly value of variable Q in quarter T), and lower case denote monthly series/time index (q_t denotes the monthly value of variable q in month t.) Quarterly values are related to monthly values by the identity

$$Q_T = (q_{3T} + q_{3T-1} + q_{3T-2})/ 3$$

[1] GDP and GDI are "flow" variables, and the BEA's quarterly values correspond to value of production/income over the quarter. The problem of allocating a quarterly flow to months within the quarter is referred to as "distribution" (that is, distributing the total quarterly over the constituent months). A related problem is "interpolation" which estimates monthly values of stock variables (such as the size of the labor force) from quarterly values. See Harvey, A.C. (1989), *Forecasting, Structural Time Series Models and the Kalman Filter*, Cambridge University Press, for a discussion of the related problems of distribution, interpolation, and temporal aggregation.

where we note that all of the variables (monthly and quarterly) are expressed at annual rates.

For the variables that we consider, Q_T and q_t are trending variables. Let S_T and s_t denote trends for the series (details discussed below). Let $\tilde{Q}_T = Q_T / S_T$ and $\tilde{q}_t = q_t / s_t$ which are approximately I(0) variables. This yields the identity:

$$\tilde{Q}_T = \frac{1}{3S_T}\begin{bmatrix} s_{3T} & s_{3T-1} & s_{3T-2} \end{bmatrix}\begin{bmatrix} \tilde{q}_{3T} \\ \tilde{q}_{3T-1} \\ \tilde{q}_{3T-2} \end{bmatrix}$$

Let x_t denote a set of monthly indicators. We model $\tilde{q}_t$ as

$$\tilde{q}_t = \beta_0 + x_t'\beta + u_t, \text{ where } u_t = \rho u_{t-1} + \varepsilon_t.$$

Conditional on the parameters, β, ρ, and σ_ε, trends S_T and s_t, and quarterly data Q_T, these two equations serve as the "measurement" and "transition" equations for a linear state-space model, and q_t can be estimated by the Kalman smoother.

The trend estimates S_T and s_t were computed by fitting a smooth curve (a cubic spline) to Q_T.

The parameters β, ρ, and σ_ε are estimated by Gaussian maximum likelihood using the Q and x data.

Each component uses a different set of x variables, which are documented in the table below. In several instances, data availability dictates that the components of x_t change during the sample period. When a change occurs, β_0, ρ and σ_ε are allow to change as well.

The same method was used to interpolate the implicit GDP deflator to compute a monthly price index.

Components of Nominal GDP

Q	Sample Period	*x*	Notes
Personal Consumption Expenditures	Full Sample	Personal Consumption Expenditures	Monthly PCE averages to Quarterly PCE. No interpolation needed
Investment: NonResidential Structures	1959:1-1992:12	CONP (Citibase); CONSTRUCT.PUT IN PLACE: TOTAL PRIVATE (MIL$,SAAR) CONFR (Citibase): CONSTRUCT.PUT IN PLACE: PRIV RESIDENTIAL BLDGS (MIL$,SAAR) x = CONP – CONFR	Citibase Series
	1993:1 – End	PRIV: Total Private Construction RES: Total Private Residential Contruction. x = PRIV – RES	Series from : RES from Census C30 Reports: http://www.census.gov/const/www/c30index.html
Investment: Equipment and Software	1959:1 – 1967:12	ATCGVS: Manufacturers Shipments: Total Capital Goods	Data are from the Census M3 releases. Historical time series available at http://www.census.gov/manufacturing/m3/historical_data/index.html SIC prior to 1992, NAICS 1992:1-2009:12
	1968:1 – 1991:12	ANDEVS: Manufacturers Shipments: Nondefense Capital Goods AITIVS: Manufacturers Shipments: Information Technology Industries	
	1992:1 – End	ANDEVS and AITIVS	
Investment: Residential Structures	1959:1-1992:12	CONFR (Citibase): CONSTRUCT.PUT IN PLACE: PRIV RESIDENTIAL BLDGS	Citibase Series
	1993:1 – End	RES: Total Private Residential Contruction.	From Census C30 Reports: http://www.census.gov/const/www/c30index.html
Investment: Change in Private Inventories	1959:1-1966:12	IVMT (Citibase): MFG & TRADE INVENTORIES: TOTAL BIL$,EOM,SA)) x = ΔIVMT	Citibase Release Nov. 1998
	1967:1-End	INVT_CHANGE: NIPA Underlying Detail Tables 5.6.5AM1 and5.6.5BM1 . Change in Private Inventories by Industry	NIPA Underlying Detail Table. Change in Private Inventories by Industry

Exports	1959:1 – 1964:12	FSE602 EXPORTS EXCLUD.MILITARY AID SHIPMENTS(MIL$,SA)(BCI602)	(Pre-1998 Citibase, from Bernanke-Gertler-Watson BPEA backup files):
	1965:1-1991:12	FSE602 EXPORTS EXCLUD.MILITARY AID SHIPMENTS(MIL$,SA)(BCI602) FTE71 :U.S.MDSE EXPORTS: NONELECTRICAL MACHINERY (MIL$,SA) (BCI Series number xxx) FTEF : U.S.MDSE (EXPORTS: AGRICULTURAL PRODUCTS (MIL$,SA) (BCI Series number xxx)	(Pre-1998 Citibase, from Bernanke-Gertler-Watson BPEA backup files):
	1992:1-2009:12	EXPORTS: Exports of goods and services, BOP Basis (SA) Millions of $s.	Available at http://www.bea.gov/international/index.htm
Imports	1959:1 – 1964:12	FSM612: GENERAL IMPORTS (MIL$, S.A.)(BCI-612)	(Pre-1998 Citibase, from Bernanke-Gertler-Watson BPEA backup files):
	1965:1-1991:12	FSM612: GENERAL IMPORTS (MIL$, S.A.) (BCI-612) FTM333 : U.S.MDSE IMPORTS: PETROLEUM & PETROLEUM PRODUCTS (MIL$,SA) (BCI Series number xxx) FTM732: U.S.MDSE IMPORTS: AUTOMOBILES & PARTS (MIL$,SA) (BCI Series number xxx)	(Pre-1998 Citibase, from Bernanke-Gertler-Watson BPEA backup files):
	1992:1-End	IMPORTS: Imports of goods and services, BOP Basis (SA) Millions of $s.	Available at http://www.bea.gov/international/index.htm
Government	1959:1-1967:12	WAGES_G: Wage and Salary Disbursements by Industry, Government, NIPA Tables 2.7A and 2.7B CONQ (Citibase): CONSTRUCT.PUT IN PLACE: TOTAL PUBLIC, (MIL.$,SAAR)	
	1968:1 – 1991:12	WAGES_G: Wage and Salary Disbursements by Industry, Government, NIPA Tables 2.7A and 2.7B CONQ (Citibase): CONSTRUCT.PUT IN	AMTMVS and AMXDVS from from the Census M3 releases. Historical time series available at http://www.census.gov/manufacturing/m3/historical_data/index.html

		PLACE: TOTAL PUBLIC, (MIL.$,SAAR) AMTMVS-AMXDVS, where AMTMVS: Manufacturing and Trade Sales: Total Manufacturing (SIC 1968-1991) AMXDVS: Manufacturing and Trade Sales: Manufacturing excluding Defense (SIC 1968-1991)	
	1992:1 – End	WAGES_G: Wage and Salary Disbursements by Industry, Government, NIPA Tables 2.7A and 2.7B CON_Gov: Total Public Construction put in place AMTMVS-AMXDVS, where AMTMVS: Manufacturing and Trade Sales: Total Manufacturing (NAICS 1992-2009) AMXDVS: Manufacturing and Trade Sales: Manufacturing excluding Defense (NAICS 1992-2009)	CON_Gov from Census C30 Reports: http://www.census.gov/const/www/c30index.html AMTMVS and AMXDVS from from the Census M3 releases. Historical time series available at http://www.census.gov/manufacturing/m3/historical_data/index.html

Components of Nominal GDI

Q	Sample Period	*x*	Notes
Employee Compensation	1959:1-End	COMPE: Compensation of Employees from monthly Personal Income	NIPA Table 2.6, line 2
Proprietors Income	1959:1-End	PROP_INC: Proprietors Income from monthly Personal Income.	NIPA Table 2.6, line 7
Rental Income	1959:1-End	Rental Income (with CCA): from monthly Personal Income Note: Current version of Table 2.6 shows no variation in monthly rents within a quarter for dates prior to January 1977. For the pre-1977 we have used series GMPREN from a previous version of CITIBASE.	NIPA Table 2.6, line 10
Net Interest	1959:1-End	INTEREST: Personal Interest Income from monthly Personal Income	NIPA Table 2.6, line 12
Corporate Profits	1959:1-End	PROP_INC: Proprietors Income from monthly Personal Income.	NIPA Table 2.6, line 7
Other GDI	1959:1-End	COMPE: Compensation of Employees from monthly Personal Income PROP_INC: Proprietors Income from monthly Personal Income.	NIPA Table 2.6, line 2 NIPA Table 2.6, line 7

GDP Price Deflator

Q	Sample Period	*x*	Notes
GDP Price Deflator	1959:1-End	PCED: PCE Price Deflator	NIPA Table 2.8.4, line 1

Replication files are available at http://www.princeton.edu/~mwatson/mgdp_gdi.html:

The replication files consist of input data (Q and x) and computer programs.

Data: All Input Data are listed in DISTRIBUTE_GDP_GDI_INPUT.XLS

Programs: (All programs use GAUSS (v10.0) and require the GAUSS program MAXLIK)

DISTRIBUTE_NOMINAL_COMPONENTS.GSS: Distributes each of the monthly components listed above

DISTRIBUTE_GDP_DEFLATOR.GSS: Distributes the GDP deflator

DISTRIBUTE_REAL_GDP_GDI.GSS: Uses output from the two programs about to compute monthly estimates of nominal and real values of GDP/GDI.