Constructing The Investment Deflator

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The goal is to construct a quarterly series for the relative price of investment from 1947:I to 2006:IV[1] following the methodology used by Fischer (2005). The relative price of investment is the ratio between a deflator of investment and the deflator of consumption. The deflator for consumption corresponds to the weighted deflator for nondurable and service consumption, service flow from consumer durables and government consumption; all taken from NIPA. The difficulty is to measure the investment deflator.

The investment deflator is a weighted average of an equipment-specific deflator and NIPA-based deflators for non-residential structures, residential structures, consumer durables, and government investment. The construction of the equipment-specific deflator involves two parts: to construct an annual series and, based on this, to construct a quarterly series.

1 The Annual Series

The equipment-specific deflator follows Cummins and Violante (2002) and is produced combining 24 series of quality adjusted prices of equipment goods constructed by Gordon (1990) and NIPA data on these goods. Of these 24, two of them the are taken directly from NIPA (Office and accounting equipment, and Software), while Computers and peripheral equipment is constructed using Gordon's series from 1947 to 1957 and NIPA for 1958 onwards.

The remaining 21 goods are the following:

1. *Industrial equipment*: Electrical transmission, distribution, and industrial apparatus; Engines and turbines; Fabricated metal products; General industrial (including materials handling) equipment; Metalworking machinery; Special industry machinery.

2. *Transportation equipment*: Autos; Aircraft; Railroad equipment; Ships and boats; Trucks, buses, and truck trailers.

3. *Other equipment*: Agricultural machinery (except tractors); Construction machinery (except tractors); Electrical equipment; Furniture and fixtures; Mining and oilfield machinery; other equipment; Service industry machinery; Tractors.

4. *Office information processing*: Communications equipment; Instruments, photocopy, and related equipment.

For these, Gordon's series is extended as follows. First, run the following regression for each good i, using data from 1947 to 1983:

$$\log\left(p_t^{i,G}\right) = c + \beta_1 t + \beta_2 \log\left(p_t^{i,N}\right) + \beta_3(L)\log\left(p_{t-1}^{i,N}\right) + \beta_4(L)\Delta y_{t-1} + \epsilon_t^i,$$

[1] Given that the series is derived from an annual series, the last available annual data is in 2006.

where c is a constant, t is a linear trend, $p^{i,G}$ is the Gordon's price, $p^{i,N}$ is the NIPA price, and Δy_t is the growth rate of GDP. The lag-length in the polynomials $\beta_3(L)$ and $\beta_4(L)$, as well as the inclusion of the trend, is chosen using the BIC.[2] The results of this exercise are presented in Tables 1 and 2. Then, using the obtained coefficients, extrapolate the series using the NIPA data from 1984 onwards.

[2]In most cases, the BIC yields the same model than AIC and LR test. When they differ, the BIC yields the more parsimonious models.

Table 1: Regression Results

	Elec tran (1)	Engn& turbn (2)	Fabr metl (3)	Gnrl eqp (4)	Metl mach (5)	Spcl mach (6)	Air (7)	Auto (8)	Rail (9)	Ship& boat (10)	Trck & bus (11)
$trend * 100$	-3.22	-6.04	-2.54	-1.09	—	-4.24	-14.97	-0.74	-0.82	-3.17	-3.56
	(0.35)	(0.76)	(0.33)	(0.24)		(0.27)	(1.26)	(0.25)	(0.15)	(0.18)	(0.24)
p_t^N	1.38	1.48	1.46	0.80	0.58	0.93	2.37	1.00	0.86	1.36	1.61
	(0.10)	(0.15)	(0.24)	(0.05)	(0.15)	(0.05)	(0.28)	(0.14)	(0.03)	(0.19)	(0.24)
p_{t-1}^N	—	—	-0.16	—	0.57	—	—	—	—	0.33	-0.50
			(0.42)		(0.23)					(0.29)	(0.25)
p_{t-2}^N	—	—	0.50	—	-0.47	—	—	—	—	-0.49	—
			(0.41)		(0.15)					(0.13)	
p_{t-3}^N	—	—	-0.77	—	—	—	—	—	—	—	—
			(0.25)								
Δy_{t-1}	—	—	-0.008	-0.009	-0.008	-0.004	—	-0.011	—	—	—
			(0.003)	(0.002)	(0.002)	(0.002)		(0.004)			
Δy_{t-2}	—	—	—	-0.006	-0.013	-0.003	—	-0.009	—	—	—
				(0.002)	(0.002)	(0.002)		(0.004)			
Δy_{t-3}	—	—	—	—	-0.005	-0.004	—	—	—	—	—
					(0.002)	(0.002)					
cons	2.18	3.60	1.82	1.36	1.03	2.44	7.19	0.93	1.38	2.38	2.22
	(0.17)	(0.36)	(0.17)	(0.12)	(0.03)	(0.13)	(0.66)	(0.13)	(0.07)	(0.09)	(0.13)
R2	0.90	0.86	0.96	0.99	0.99	0.96	0.96	0.81	0.99	0.99	0.95
R2 adj	0.89	0.85	0.95	0.99	0.99	0.95	0.96	0.78	0.99	0.99	0.95

Table 2: Regression Results, Cont.

	Argc mach (12)	Cnst mach (13)	Elec eqp (14)	Furn (15)	Mine & oil (16)	Othr eqp (17)	Srvc mach (18)	Trctr (19)	Comm eqp (20)	Inst& photo (21)
$trend * 100$	—	-1.90	0.33	-0.86	-0.75	-0.58	-4.53	—	-6.58	—
		(0.19)	(0.15)	(0.19)	(0.20)	(0.24)	(0.14)		(0.39)	
p_t^N	2.17	0.94	0.87	1.00	0.71	1.31	1.22	0.69	1.62	-0.71
	(0.21)	(0.04)	(0.06)	(0.05)	(0.04)	(0.33)	(0.05)	(0.27)	(0.15)	(0.08)
p_{t-1}^N	-1.15	—	—	—	—	0.23	—	1.05	—	—
	(0.22)					(0.63)		(0.48)		
p_{t-2}^N	—	—	—	—	—	0.50	—	-0.46	—	—
						(0.63)		(0.46)		
p_{t-3}^N	—	—	—	—	—	-1.42	—	-0.60	—	—
						(0.36)		(0.28)		
Δy_{t-1}	-0.007	-0.007	—	-0.006	-0.007	—	—	0.015	—	—
	(0.002)	(0.002)		(0.002)	(0.002)			(0.003)		
Δy_{t-2}	—	—	—	—	-0.005	—	—	—	—	—
					(0.002)					
Δy_{t-3}	—	—	—	—	—	—	—	—	—	—
cons	1.36	1.87	0.68	1.41	1.28	0.69	2.45	0.90	2.05	-0.47
	(0.04)	(0.09)	(0.08)	(0.10)	(0.09)	(0.16)	(0.08)	(0.07)	(0.13)	(0.08)
R2	0.99	0.99	0.96	0.99	0.99	0.95	0.98	0.99	0.93	0.82
R2 adj	0.99	0.99	0.95	0.99	0.99	0.94	0.98	0.99	0.93	0.81

At this point, we have 24 annual price series p_t^i for $i = 1, ..., 24$, for the period 1947-2006. In order to produce an index for equipment, we first need to construct the share of each good s_t^i. This share is the ratio of the current dollar value of investment in good i and the current dollar value of total private nonresidential equipment and software investments; constructed using NIPA data. With these, the change in the index is calculated as,

$$\Delta \log(p_t) = \sum_{i=1}^{24} \log\left(\frac{p_t^i}{p_{t-1}^i}\right)\left(\frac{s_t^i + s_{t-1}^i}{2}\right),$$

and the level is computed by

$$\log(p_t) = \log(p_{t-1}) + \Delta \log(p_t).$$

We will use this formula to construct all the required indexes.

2 The Quarterly Series

Given the annual series, the second step is to construct a quarterly series. Fischer applies a method presented in Fernandez (1981), which basically uses information in a higher frequency indicator variable to interpolate a better quality but lower frequency variable. In this case, the quarterly series used for the interpolation is the NIPA equipment deflator.

The procedure works as follows. Let Y be a $m \times 1$ vector of annual observations and let Z be a $n \times q$ a matrix of higher frequency variables that are related with Y. The frequency of these is $k \equiv n/m$. The goal is to construct a $n \times 1$ vector X, which is a higher frequency version of Y, that satisfies that the sum (or the average) for the year must equal annual observation. These two will then be related by $Y = B'X$ where $B \equiv I_m \otimes j$ and j is a $k \times 1$ vector of ones (if we want to match the annual average we use j/k).

The method then consists in choosing X and β to minimize $(X - Z\beta)'A(X - Z\beta)$, where A is a symmetric $n \times n$ non-singular matrix specified below. The resulting estimates are:

$$\hat{\beta} = \left[Z'B\left(B'A^{-1}B\right)^{-1}B'Z\right]^{-1} Z'B\left(B'A^{-1}B\right)^{-1}Y,$$

$$\hat{X} = Z\hat{\beta} + A^{-1}B\left(B'A^{-1}B\right)^{-1}\left[Y - B'Z\beta\right]$$

According to Fernandez (1981), the most common choice for the matrix A is $A = D'D$ where D is a $n \times n$ matrix defined as,

$$D = \begin{bmatrix} 1 & 0 & 0 & \dots & 0 & 0 \\ -1 & 1 & 0 & \dots & 0 & 0 \\ 0 & -1 & 1 & \dots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & \dots & -1 & 1 \end{bmatrix}.$$

What this matrix is doing is to convert the values for X and Z into first differences, which implies that the objective function is to minimize the squared difference between the first difference of the estimated series X and the first difference of the high frequency series Z. Additionally, this choice has the advantage that $D^{-1} = R'$, where R is an upper triangular matrix with non-zero elements equal to one; which yields $A^{-1} = R'R$, simplifying the computations.

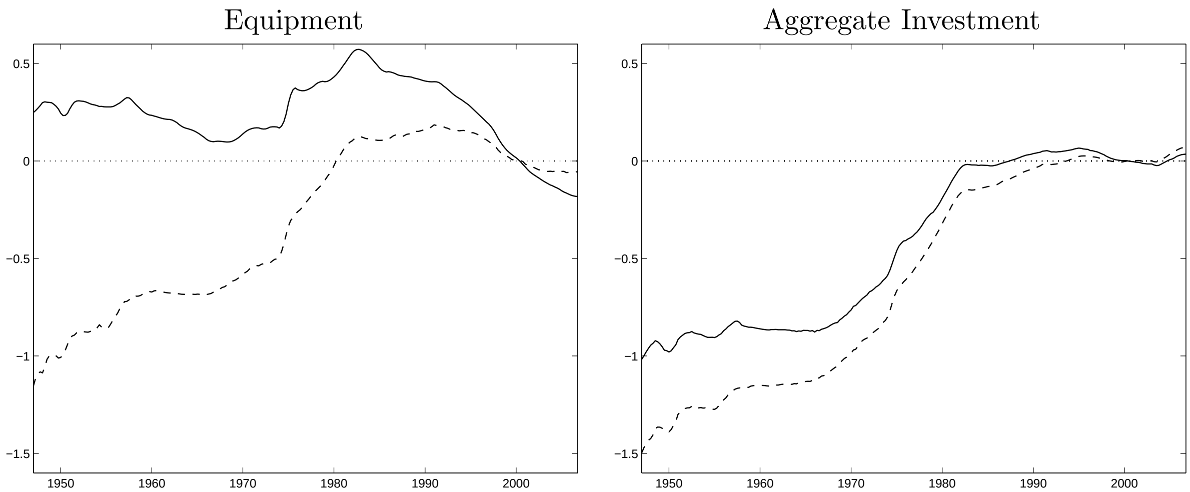
3 Price for Consumer Durables

For this series, Fischer combines a series constructed by Gordon and NIPA data. Specifically, the annual series from Gordon from 1947 to 1983 is interpolated using the quarterly NIPA index to obtain a quarterly series. For the rest of the sample the NIPA index is used.

4 Results

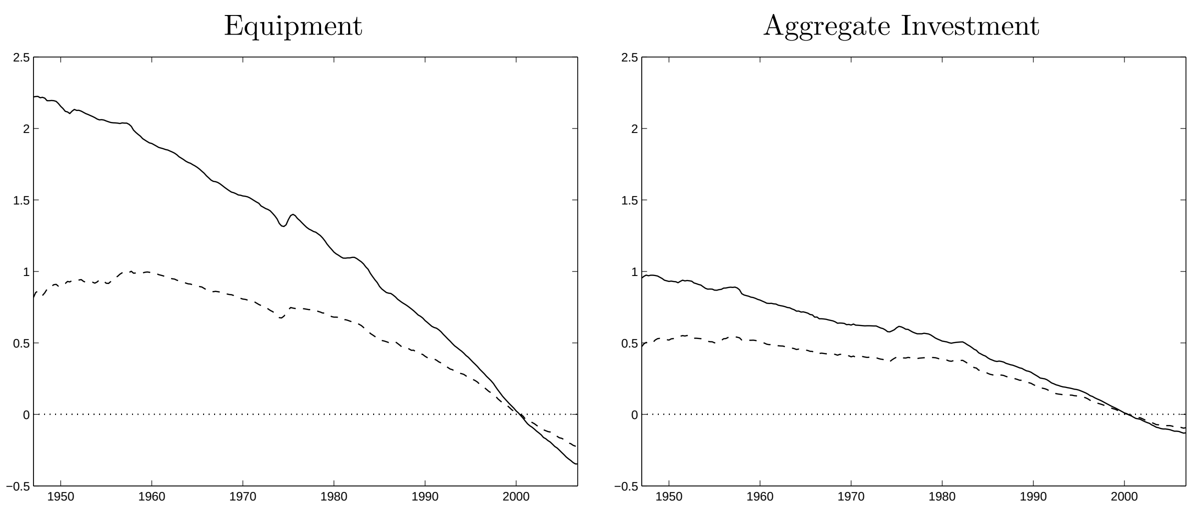
The resulting series are plotted in Figures 1 and 2. For comparative purposes, the data created by Fischer is available online on the website of the paper by Altig *et al.* (2004), for the period 1947:I to 2001:IV. Table 3 shows the correlation between both sources.

Figure 1: Nominal Investment Prices (Base=2000), 1947:I 2006:IV



Note: Solid line: Computed Series. Dashed line: NIPA.

Figure 2: Real Investment Prices (Base=2000), 1947:I 2006:IV



Note: Solid line: Computed Series. Dashed line: NIPA.

Table 3: Correlation between ACEL series and our series

Equipment	Investment	Consumption
0.9874	0.9985	0.9997

5 NIPA Sources

In terms of equipment goods, all the ones listed in Table 4 were collected from the same file. The other three NIPA series where constructed as follows. For `L_AGRIC` (Agricultural machinery, except tractors), from 1947-2001, the price series comes from the supplemental tables of the release of 2002,[3] folder `708 Year`, series `B268RG`; and the dollar series comes from the underline tables of the release of 2002,[4] folder `508 Year`, series `C268RC`. From 2001-2005, Both series from the underline tables of the release of 2007,[5] the prices are in folder `554U Ann`, series `W213RG3`; and the dollars are in folder `555U Ann`, series `W213RC0`. For `L_CONSTR` (Construction machinery, except tractors), the series are distributed in the same files and folders as with `L_AGRIC`.

Table 4: NIPA Equipment data

Variable Name	NIPA Definition	Code for price	Code for dollars
L_AIRCF	Aircraft	B281RG3	B281RC1
L_AUTO	Autos	B280RG3	B280RC1
L_COMM	Communications equipment	B275RG3	B275RC1
L_ELECTR	Electrical equipment	B670RG3	B670RC1
L_ENG	Engines and turbines	B668RG3	B668RC1
L_ETDIA	Electrical transmission, distribution, and industrial apparatus	B276RG3	B276RC1
L_FMP	Fabricated metal products	B263RG3	B263RC1
L_FURNIT	Furniture and fixtures	B667RG3	B667RC1
L_GIE	General industrial (including materials handling) equipment	B273RG3	B273RC1
L_MINE	Mining and oilfield machinery	B270RG3	B270RC1
L_MWM	Metalworking machinery	B271RG3	B271RC1
L_OTHEQ	Other equipment	B286RG3	B286RC1
L_RAIL	Railroad equipment	B283RG3	B283RC1
L_SERV	Service industry machinery	B570RG3	B570RC1
L_SHIP	Ships and boats	B282RG3	B282RC1
L_SPEC	Special industry machinery	B272RG3	B272RC1
L_TRUCK	Trucks, buses, and truck trailers	B279RG3	B279RC1
L_OFFACC	Office and accounting equipment	B936RG3	B936RC1
L_COMPU	Computers and peripheral equipment *	B935RG3	B935RC1
L_SOFT	Software *	B985RG3	B985RC1

The folder name in the Excel file is `50504 Ann` for prices and `50505 Ann` for dollars. *These series are available starting in 1959. The excel file can be found at: http://www.bea.gov/histdata/Releases/GDP_and_PI/2007/Q2/Preliminary_August-30-2007/Section5ALL_xls.xls

The price series for `L_TRACT` (Tractors) for 1947-2001 is taken the supplemental tables of the release of 2002, folder `708 Year`, series `B669RG`. The dollar amount for this series comes from the underline tables of the release of 2002, folder `508 Year`, series `A669RC`. From 2001-2005, we combine two series, both in the underline tables of the release of 2007, Construction tractors (Price: folder `554U Ann` series `BA18RG3`, Dollars: folder `555U Ann` series `BA18RC0`); and Farm tractors (Price: folder `554U Ann` series `BA17RG3`, Dollars: folder `555U Ann` series `BA17RC0`).

The final equipment good constructed by Gordon is `L_INSPHO` (Instruments, photocopy, and

[3] This file can be found at: http://www.bea.gov/histdata/Releases/GDP_and_PI/2002/Q2/Final_September-27-2002/Section7ALL_xls.xls

[4] This file can be found at: http://www.bea.gov/histdata/Releases/GDP_and_PI/2002/Q2/Final_September-27-2002/Section5ALL_xls.xls

[5] This file can be found at: http://www.bea.gov/histdata/Releases/GDP_and_PI/2007/Q2/Preliminary_August-30-2007/und/Section5ALL_xls.xls

related equipment). ¿From 1947-2001, we combine two series: Instruments and Photocopy and related equipment. The prices comes the supplemental tables of the release of 2002 (folder `708 Year`); and the dollars from the underline tables of the release of 2002 (folder `508 Year`).

From 2001-2005, we combine three series, both in the underline tables of the release of 2007: Medical equipment and instruments, Nonmedical instruments, and Photocopy and related equipment (prices from folder `50504 Ann` and dollars from folder `50505 Ann`).

For the other series used for the investment deflator, Equipments, Non-residential structures and Residential structures are from the underline tables of the release of 2007 (folder `50304 Qtr` for prices and `50305 Qtr` for dollars). Consumer durables are from the Tables 1 of the release of 2007[6] (folder `10104 Qtr` for prices and `10105 Qtr` for dollars), and government investment are from Tables 3 of the release of 2007[7] (folder `30904 Qtr` for prices and `30905 Qtr` for dollars)

Finally, the series used for the consumption deflator are: Government Consumption (Tables 3 of the release of 2007, folder `30904 Qtr` for prices and `30905 Qtr` for dollars), Private Consumption of Non-Durables and Services (folder `50304 Qtr` for prices and `50305 Qtr` for dollars), and the Service Flow from Consumer Durables (real service flow obtained from David Reifschneider at the Board of Governors, converted to nominal terms with the price index for durable consumption goods described above).

[6]This file can be found at: http://www.bea.gov/histdata/Releases/GDP_and_PI/2007/Q2/Preliminary_August-302007/Section1ALL_xls.xls

[7]This file can be found at: http://www.bea.gov/histdata/Releases/GDP_and_PI/2007/Q2/Preliminary_August-302007/Section3ALL_xls.xls