10 Prices

10.1 Introduction

In this chapter the price equation of the model will be discussed. The price equation provides the link between predictions of money GNP and predictions of real GNP. There is no feedback in the model from the price sector to the money GNP sector, and the causality runs from predictions of money GNP, to predictions of the price deflator, to predictions of real GNP. Real GNP is determined simply as money GNP divided by the price deflator. Real GNP is thus the "residual" in the model: it is determined from a simple definition once money GNP and the price level have been determined.

In most macroeconomic models prices are determined in a wage–price sector by various cost and excess demand variables. Unfortunately, in many of these models the wage–price sector has tended to be a large source of error.[1] Because of the simultaneous and lagged relationships between wages and prices, the wage–price sector is difficult to specify and estimate with precision, and in simulation the possibilities for error compounding in the sector are generally quite large. In the present model the whole wage–price nexus has been avoided, and prices have been assumed to be determined simply by current and past demand pressures. The price equation of the model can thus be considered to be a reduced form equation of a more general wage–price model. The equation is also similar to simple Phillips curve equations, where wage changes (or price changes) are taken to be a function of excess supply (as approximated by the unemployment rate) in the labor market.

Potential output plays an important role in the price sector, and the concept and measurement of potential output will be discussed in Section 10.2. The theory upon which the price equation is based will then be discussed in Section 10.3 and the results of estimating the equation will be presented. The chapter concludes in Section 10.4 with a discussion of how real GNP is computed. Some of the discussion in Sections 10.2 and 10.3 follows closely the discussion in Sections I and II of Fair [15]. Also, the development of a potential output series in Section 10.2 relies heavily on the work in the previous chapter.

[1] See, for example, Fromm and Taubman [24], p. 11, for a discussion of the difficulties encountered by the Brookings model in this area.

10.2 The Concept and Measurement of Potential Output

In Chapter 9 the production function (9.2) was derived under the assumption of no short-run substitution possibilities between workers and machines and constant short-run returns to scale. The production function is rewritten here for convenience:

$$Y_t = \alpha_t M_t H_t . \tag{9.2}$$

Y_t denotes private nonfarm output, M_t denotes private nonfarm employment, and H_t denotes the number of hours actually worked per private nonfarm worker. The production function parameter α_t was estimated in the manner described in Section 9.2.

"Potential nonfarm output" is defined in this study to be that level of output which results from equation (9.2) when the potential values of M_t and H_t are used in the equation. The potential values of M_t and H_t are defined to be the values that would occur at a 4 percent unemployment rate. "Potential output" is thus not meant to connote "maximum output." Output greater than potential could always be produced by using greater than potential values of M_t and H_t. "Potential output" is rather meant to refer to that level of output that is capable of being produced by working people at rates that have been observed to occur during periods when the unemployment rate was 4 percent.

In order to use equation (9.2) to develop a potential nonfarm output series, a potential nonfarm man-hours series has to be derived. In addition, since a potential GNP series is needed for the work below, series on potential government output and potential agricultural output have to be derived. It will be seen below that series on potential government employment and potential agricultural employment also have to be derived. In the following discussion, the potential output and employment series for the government and agricultural sectors will be derived first. Then a series on the potential number of private nonfarm workers employed will be derived, followed by the derivation of a series on the potential number of hours worked per private nonfarm worker. These latter two series then allow a series on potential private nonfarm output to be derived using the production function (9.2). The potential GNP series is then taken to be the sum of the three potential output series.

The variables that are used in the price sector are listed in Table 10–1. Many of the variables are the same as those used in the employment and labor force sector. The new variables that have been added are real agricultural output, YA_t; real government output, YG_t; government output in

Table 10–1. List and Description of the Variables Used in the Price Sector.

For the Potential GNP Calculations	
AF_t	= Level of the Armed Forces in thousands
P_{1t}	= Noninstitutional Population of males 25–54 in thousands
P_{2t}	= Noninstitutional Population of all others over 16 in thousands
MCG_t	= Civilian Government Employment in thousands of workers, SA
YG_t	= Government Output in billions of 1958 dollars, SA, annual rates
LF_{1t}^*	= Potential Level of the Primary Labor Force (males 25–54) in thousands, SA
LF_{2t}^*	= Potential Level of the Secondary Labor Force (all others over 16) in thousands, SA
E_t^*	= Potential Level of Total Civilian Employment in thousands of workers, SA
MA_t^*	= Potential Level of Agricultural Employment in thousands of workers, SA
M_t^*	= Potential Level of Private Nonfarm Employment in thousands of workers, SA
H_t^*	= Potential Number of Hours Worked per Private Nonfarm Worker in hours per week per worker, SA
Y_t^*	= Potential Private Nonfarm Output in billions of 1958 dollars, SA, annual rates
YA_t^*	= Potential Agricultural Output in billions of 1958 dollars, SA, annual rates
$GNPR_t^*$	= Potential GNP in billions of 1958 dollars, SA, annual rates
Other Variables Used in the Price Sector	
PD_t	= Private Output Deflator in units of 100, SA
GNP_t	= GNP in billions of current dollars, SA, annual rates
$GNPR_t$	= GNP in billions of 1958 dollars, SA, annual rates
GG_t	= Government Output in billions of current dollars, SA, annual rates
YA_t	= Agricultural Output in billions of 1958 dollars, SA, annual rates

Note: SA = Seasonally Adjusted

money terms, GG_t; real GNP, $GNPR_t$; and the private output deflator, PD_t. The data on these variables are described in Table 10–1. The data on the five new variables are national income accounts data and are currently published in the *Survey of Current Business*. The asterisk after a variable in the table denotes the potential value of the variable.

Potential Output and Employment in the Government and Agricultural Sectors

The potential values for government output, YG_t, and government employment (both civilian, MCG_t, and noncivilian, AF_t) have been taken to be equal to the actual values of these variables.

With respect to the agricultural sector, potential agricultural output and the potential number of agricultural workers employed were derived in the following manner. Agricultural output, YA_t, was first plotted for the 471–694 period, and the series was interpolated peak to peak. The interpolated series was then taken as the potential agricultural output series (denoted as YA_t^*). Agricultural output per worker, YA_t/MA_t, was next plotted for the 471–694 period, and a peak-to-peak interpolation of this series was made (denoted as PA_t^*). Finally, YA_t^* was divided by PA_t^* to yield a series on the potential number of agricultural workers employed (denoted as MA_t^*). Fortunately, the agricultural sector is small enough relative to the total economy so that the measurement of total potential output is not very sensitive to how the agricultural sector is treated. The treatment in this study has the advantage of smoothing out the erratic fluctuations that occur in the YA_t and MA_t series, many of which are undoubtedly due to measurement error.[2]

Potential Employment in the Private Nonfarm Sector

The derivation of the series on the potential number of private nonfarm workers employed (to be denoted as M_t^*) is based on equations (9.9), (9.10), (9.11), and (9.12) in Chapter 9. Equations (9.11) and (9.12) are the two labor force participation equations; equation (9.9) defines D_t, the difference between the establishment data and the household survey data; and equation (9.10) explains D_t as a function of a time trend and M_t. For convenience, the two labor force participation equations are repeated here:

$$\frac{LF_{1t}}{P_{1t}} = .981 - .000190t, \tag{9.11}$$

$$\frac{LF_{2t}}{P_{2t}} = .180 + .000523t + .447\frac{E_t + AF_t}{P_{1t} + P_{2t}}. \tag{9.12}$$

Also, equations (9.9) and (9.10) can be solved to eliminate D_t and to write M_t as a function of E_t, MA_t, and MCG_t. This solution is:

$$M_t = \frac{1}{1 - .358}(E_t - MA_t - MCG_t - 13014 - 71.10t). \tag{10.1}$$

Using equations (9.11), (9.12), and (10.1), the M_t^* series was derived in the following manner. In equation (9.12), $(E_t + AF_t)/(P_{1t} + P_{2t})$ was set equal to .586 for all values of t. The number .586 is the approximate value that the employment-population ratio reached when the unemployment rate was 4 percent. Using this value and taking P_{2t} to be exogenous, the potential labor force of secondary workers (denoted as LF_{2t}^*) was calculated from

[2] See footnote 5 and related discussion in Chapter 9.

equation (9.12). The potential labor force of primary workers (denoted as LF_{1t}^*) was calculated directly from equation (9.11), taking P_{1t} to be exogenous. The potential civilian labor force was then calculated as $LF_{1t}^* + LF_{2t}^* - AF_t$ (AF_t being treated as exogenous). Potential civilian (household survey) employment (denoted as E_t^*) was next calculated as .96 ($LF_{1t}^* + LF_{2t}^* - AF_t$), where .96 is the employment rate corresponding to a 4 percent unemployment rate. Given E_t^* and given the series on potential agricultural employment, MA_t^*, computed above, the series on potential private nonfarm employment, M_t^*, was computed from equation (10.1) (MCG_t being treated as exogenous).

It should be stressed that while the derivation of M_t^* is based on equations (9.11), (9.12), and (10.1), it is not based on the *predictions* of LF_{1t}, LF_{2t}, D_t, E_t, and M_t from the employment and labor force sector. The coefficient estimates of the equations have merely been used in the derivations, along with the data on the exogenous variables, P_{1t}, P_{2t}, AF_t, and MCG_t. It should also be noted that the estimates of the serial correlation coefficients of the equations have not been used in the derivations.

The Potential Number of Hours Worked per Private Nonfarm Worker

The potential number of hours worked per private nonfarm worker will be denoted as H_t^*. In the previous chapter H_t^* was used to denote the standard or desired number of hours of work per worker. Given the assumption made about the standard number of hours of work in equation (9.6) and given the coefficient estimates in equation (9.8), a series on the standard number of hours of work can be constructed. This was done for the estimates of M_t^d presented in Table 9–2. For the work in this chapter the potential number of hours of work per worker could be taken to be the same as the standard number. In fact, a slightly different approach was followed here. The number of hours paid-for per worker, HP_t, was regressed on a constant and time for the 471–694 period and the predicted values from this equation were taken as the values for H_t^*. The equation was

$$HP_t = \underset{(855.87)}{41.05} - \underset{(35.77)}{.032t}, \qquad SE = .23. \qquad (10.2)$$

The estimation of the production parameter α_t in Chapter 9 was based on the assumption that hours paid-for per worker are greater than hours worked per worker except during peak output periods, and thus it does not seem unreasonable to take the potential number of hours worked per worker to be equal to the trend number of hours paid-for per worker. The values of

H_t^* achieved in this way are actually quite similar in concept to values that would have been achieved had H_t^* been taken to be equal to the constructed standard number of hours of work per worker, and the results below would have been quite similar regardless of which series had been used. The approach followed in this chapter is slightly more straightforward, and this is the reason for its use here.

Consistent with the derivation of M_t^* above, one also might use an interpolation of the hours paid-for per worker series as the series for H_t^*, where the benchmark quarters were chosen as those quarters in which the unemployment rate was approximately 4 percent. However, the value of hours paid-for during quarters in which the unemployment rate was approximately 4 percent showed no apparent consistency—the value was sometimes below trend and sometimes above trend—and this idea was therefore dropped from further consideration.

Potential Nonfarm Output and Potential Real GNP

The estimates of M_t^* and H_t^* constructed above can be multiplied together to yield a series on potential private nonfarm man hours, $M_t^* H_t^*$. Using the production function (9.2) and the estimates of α_t from Chapter 9, a series on potential private nonfarm output (denoted as Y_t^*) can then be constructed. Finally, potential real GNP (denoted as $GNPR_t^*$) can be calculated as the sum of potential private nonfarm output, potential agricultural output, and government output:

$$GNPR_t^* = Y_t^* + YA_t^* + YG_t. \tag{10.3}$$

In Table 10–2 the actual values of real GNP (denoted as $GNPR_t$), the values of $GNPR_t^*$, and the percentage changes in $GNPR_t^*$ (at annual rates) are presented quarterly for the 541–694 period.[3] Note that $GNPR_t^*$ grew less than average during late 1965 and 1966. This was due primarily to the Vietnam troop buildup during this period. As measured by the national income accounts, average output per government worker is less than average output per private worker, so that the movement of workers from private to government work (as when the level of the armed forces is increased) has a negative effect on total potential output. In general, the $GNPR_t^*$ series in Table 10–2

[3] The potential GNP numbers in Table 10–2 differ slightly from the numbers presented in Table 1 of Fair [15] because of different periods of estimation used to estimate the D_t, LF_{1t}/P_{1t}, and LF_{2t}/P_{2t} equations.

Table 10–2. Estimates of Potential Real GNP (billions of 1958 dollars).

Quarter	$GNPR_t$	$GNPR_t^*$	$\frac{4\Delta GNPR_t^*}{GNPR_{t-1}^*}$	Quarter	$GNPR_t$	$GNPR_t^*$	$\frac{4\Delta GNPR_t^*}{GNPR_{t-1}^*}$
541	402.9	427.1	.037	621	519.5	468.3	.026
542	402.1	430.7	.033	622	527.7	573.3	.035
543	407.2	433.9	.030	623	533.4	579.5	.043
544	415.7	437.6	.034	624	538.3	585.9	.045
551	428.0	441.7	.037	631	541.2	592.9	.047
552	435.4	445.7	.037	632	546.0	599.1	.042
553	442.1	450.1	.039	633	554.7	604.6	.037
554	446.4	454.0	.035	634	562.1	609.3	.031
561	443.6	457.5	.031	641	571.1	615.6	.041
562	445.6	461.1	.031	642	578.6	621.2	.037
563	444.5	465.4	.037	643	585.8	627.3	.039
564	450.3	469.0	.031	644	588.5	632.4	.032
571	453.4	472.5	.030	651	601.6	638.2	.037
572	453.2	476.6	.034	652	610.4	643.9	.036
573	455.2	481.5	.041	653	622.5	648.4	.028
574	448.2	486.7	.043	654	636.6	653.0	.028
581	437.5	491.2	.037	661	649.1	656.3	.020
582	439.5	495.3	.033	662	655.0	659.7	.021
583	450.7	499.3	.032	663	660.2	663.9	.026
584	461.6	504.3	.040	664	668.1	667.7	.023
591	468.6	508.5	.033	671	666.5	673.0	.032
592	479.9	513.6	.040	672	670.5	678.5	.032
593	475.0	518.5	.038	673	678.0	686.1	.045
594	480.4	522.5	.031	674	683.5	692.2	.036
601	490.2	530.7	.063	681	693.3	698.0	.033
602	489.7	535.5	.036	682	705.8	703.7	.032
603	487.3	540.1	.034	683	712.8	710.1	.037
604	483.7	545.6	.041	684	718.5	716.6	.036
611	482.6	551.2	.041	691	723.1	723.6	.039
612	492.8	556.3	.037	692	726.7	729.9	.035
613	501.5	561.2	.035	693	730.6	737.6	.042
614	511.7	564.6	.024	694	729.8	744.5	.038

is fairly smooth, but it is by no means as smooth as a simple trend measure like that of the Council of Economic Advisers.

The measurement of potential output in this chapter differs from that of Black and Russell [2] in two basic respects. First, the man-hours series used in this study covers only the private nonfarm sector, whereas Black and Russell derive a series for the total economy including the armed forces. The private nonfarm man-hours and output series are of greater reliability than the series for the total economy, and this is the reason why only the private nonfarm data were used to derive the above estimates of potential productivity. The second way the measurement of potential output in this study differs from that of Black and Russell is that the above estimates of potential productivity are based on the idea that the number of hours paid-for per worker does not equal the number of hours actually worked per worker except during peak output periods. Black and Russell do not distinguish between these two concepts and attempt to estimate the parameters of their production function directly. The defense of the idea that hours paid-for do not equal hours worked is made in Fair [19] and will not be repeated here.

10.3 The Price Equation

The Theory

The theory behind the specification of the price equation is simple. Aggregate price changes are assumed to be a function of current and past demand pressures. Current demand pressures have an obvious effect on current prices. If current demand is strong relative to the available supply, prices are likely to be bid (or set) higher, and if current demand is weak relative to the available supply, prices are likely to be bid (or set) lower.

There are two ways in which past demand pressures can affect current prices. One way is through the lagged response of individuals or firms to various economic stimuli. It may take a few quarters for some individuals or firms to change their prices as a result of changing demand conditions. This may, of course, not be irrational behavior, since people may want to determine whether a changed demand situation is likely to be temporary or permanent before responding to it. The other way in which past demand pressures can affect current prices is through input prices. If, for example, past demand pressures have caused past input prices to rise, this should lead to higher current output prices, as higher production costs are passed on to the customer. The lag in this case is the time taken for higher input prices to lead to higher costs of production[4] and for higher costs of production to lead to higher output prices. It may also take time for input prices to respond to demand pressures, which will further lengthen the lag between demand pressures and output prices.

Note that nothing specifically has been said about wage rates. Labor is treated like any other input—demand pressures are assumed to lead (usually with a lag) to higher wage rates, which then lead (perhaps with a lag) to higher output prices. The present approach avoids the problem of having to determine unit labor costs or wage rates before prices can be determined.

The first question which arises in specifying the price equation is what measure of demand pressure should be used. Two measures, denoted as

[4] Since firms stockpile various inputs, this lag is not necessarily zero.

$GAP1_t$ and $GAP2_t$ respectively, were considered in the work in [15]:

$$GAP1_t = GNPR_t^* - GNPR_t, \qquad (10.4)$$

$$GAP2_t = GNPR_t^* - GNPR_{t-1} - (GNP_t - GNP_{t-1}). \qquad (10.5)$$

$GAP1_t$ as defined by (10.4) is the difference between potential and actual real GNP and is a commonly used measure of demand pressure. $GNPR_t^* - GNPR_{t-1}$ in (10.5) is the change in real GNP during period t that would be necessary to make $GNPR_t$ equal to $GNPR_t^*$ (to be referred to as the "potential real change in GNP"), and $GNP_t - GNP_{t-1}$ is the actual change in money GNP during period t. $GAP2_t$ as defined by (10.5) is thus the difference between the potential real change in GNP and the actual money change. $GAP2_t$ can also be considered to be a measure of demand pressure. If, for example, the potential real change in GNP is quite large, then the money change can be quite large and still lead to little pressure on available supply, but if the potential real change is small, then even a relatively small money change will lead to pressures on supply.

The results of using both GAP1 and GAP2 as the excess demand variable for the price equation are presented and discussed in Fair [15]. It turned out that the use of GAP2 led to somewhat better results, although both sets of results were reasonable. Since money GNP is determined before prices in the present model, GAP2, which includes current money GNP but not current real GNP in its definition, is the logical variable to use in the model. GAP2 has thus been used in the work below.

The Equation

The price deflator that is explained in the model is the private output deflator (denoted as PD_t), rather than the GNP deflator. Because of the way the government sector is treated in the national income accounts, the GNP deflator is influenced rather significantly by government pay increases, such as those that occurred in 683 and 693, and PD_t is likely to be a better measure of the aggregate price level.[5]

[5] The fact that the private output deflator is used as the price variable might imply that the demand pressure variable should be net of government output. Note from equation (10.4) that $GAP1_t$ is net of government output, since government output is included in both $GNPR_t^*$ and $GNPR_t$. It can be seen from equation (10.5), however, that $GAP2_t$ is not net of government output. When, for example, a government pay increase occurs, government output in money terms is increased by this amount (and thus GNP_t is increased), but government output in real terms is not affected (and thus $GNPR_t^*$ is not affected). A government pay increase thus has a negative effect on $GAP2_t$. For the work below, government output was not netted from $GAP2_t$, since it seemed reasonable to suppose that government pay increases and the like have a positive effect on the excess demand status of the private output market. In practice, however, using $GAP2_t$ net of government output produced results almost identical to those reported below using $GAP2_t$ directly.

In Table 10–3 values of PD_t, PD_{t-1}, and $GAP2_t$ are presented quarterly for the 561–694 period. Notice that $GAP2_t$ was quite large during the early 60s when there was little increase in the aggregate price level, and that it was much smaller (and in fact negative) during the late 60s when the price level was increasing quite rapidly. (Low values of $GAP2_t$ correspond to periods of high demand pressure.)

Table 10–3. Values of PD_t, $PD_t - PD_{t-1}$, and $GAP2_t$.

Quarter	PD_t	$PD_t - PD_{t-1}$	$GAP2_t$	Quarter	PD_t	$PD_t - PD_{t-1}$	$GAP2_t$
561	93.15	.94	9.3	631	105.38	.30	49.2
562	93.97	.82	11.9	632	105.70	.31	51.1
563	95.14	1.17	15.4	633	105.88	.18	48.1
564	95.89	.75	15.6	634	106.23	.34	43.5
571	96.87	.98	14.8	641	106.47	.24	41.6
572	97.52	.65	20.2	642	106.82	.35	39.8
573	98.45	.93	21.9	643	107.21	.40	37.8
574	98.82	.37	36.3	644	107.70	.49	40.4
581	99.52	.70	49.8	651	108.24	.54	32.0
582	99.77	.25	54.2	652	108.77	.52	29.4
583	100.07	.30	46.7	653	108.96	.19	22.6
584	100.48	.40	40.6	654	109.30	.35	11.6
591	100.99	.51	37.3	661	110.08	.78	.2
592	101.23	.25	32.1	662	111.15	1.07	−3.2
593	101.64	.41	41.5	663	112.03	.88	−3.7
594	101.78	.14	41.0	664	112.91	.88	−7.3
601	102.24	.46	37.8	671	113.52	.60	1.4
602	102.67	.43	43.6	672	114.09	.58	2.7
603	102.84	.17	50.9	673	115.21	1.12	−1.3
604	103.34	.50	59.2	674	116.26	1.05	−1.5
611	103.58	.24	67.2	681	117.24	.98	−4.7
612	103.61	.03	62.4	682	118.39	1.15	−13.0
613	103.59	−.02	59.1	683	119.41	1.03	−13.4
614	104.10	.51	49.6	684	120.61	1.20	−12.3
621	104.44	.34	46.5	691	122.02	1.41	−11.1
622	104.58	.14	44.4	692	123.57	1.55	−9.3
623	104.79	.22	44.6	693	124.98	1.41	−7.1
624	105.09	.30	44.9	694	126.34	1.36	4.5

The basic equation explaining the change in the deflator has been taken to be

$$PD_t - PD_{t-1} = a_0 + a_1\left(\frac{1}{a_2 + \frac{1}{8}\sum_{i=1}^{8} GAP2_{t-i+1}}\right) + e_t, \qquad (10.6)$$

where e_t is the error term.

$$\frac{1}{8}\sum_{i=1}^{8} GAP2_{t-i+1}$$

is the simple eight-quarter moving average of GAP2. Equation (10.6) is consistent with the theory expounded above. The current change in the price level is taken to be a function of current and past demand pressures as measured by the eight-quarter moving average of GAP2. A nonlinear functional form has been chosen, the functional form being similar to that used in studies of the Phillips curve, where the reciprocal of the unemployment rate is most often used as the explanatory variable.

Equation (10.6) is nonlinear in a_2 and must be estimated by a nonlinear technique. In studies of the Phillips curve, where the reciprocal of the unemployment rate is most often taken to be the explanatory variable, a coefficient like a_2 in (10.6) does not arise, since it is assumed that as the unemployment rate (excess supply) approaches zero, the change in wages (or prices) approaches infinity. In the present case, no such assumption can be made. GAP2 is a simple and highly aggregative measure of demand pressure, and there is no reason why zero values of GAP2 should correspond to infinite changes in PD_t. Indeed, GAP2 has actually been negative during part of the sample period, as can be seen from Table 10–3. Remember that potential GNP is not meant to refer to maximum GNP, but to that GNP level that is capable of being produced when the unemployment rate is 4 percent. Including a_2 in equation (10.6) allows the equation to *estimate* the value of the moving average variable that would correspond to an infinite rate of change of prices. Another way of looking at this is that including a_2 in equation (10.6) allows the excess demand variable in the equation to differ from the "true" measure of excess demand ("true" meaning that zero values of this variable correspond to infinite price changes) by some constant amount and still not bias the estimates of a_0 and a_1. The error will merely be absorbed in the estimate of a_2.

The Results

Equation (10.6) was estimated for the 561–694 period (excluding the six strike observations, 593, 594, 601, 644, 651, and 652) using a standard iterative technique. The equation to be estimated is first linearized by means of a Taylor series expansion around an initial set of parameter values. Using the linear equation, the difference between the true value and the initial value of each of the parameters is then estimated by ordinary least squares. The procedure is repeated until the estimated difference for each of the parameters is within some prescribed tolerance level. Convergence is not garanteed using this technique, but for the work in this chapter achieving convergence was no problem.

The results were[6]

$$PD_t - PD_{t-1} = \underset{(1.44)}{-1.037} + \underset{(1.19)}{165.76}\left(\frac{1}{\underset{(2.00)}{78.36} + \frac{1}{8}\sum_{i=1}^{8} GAP2_{t-i+1}}\right) \tag{10.7}$$

$$DW = 1.78$$
$$R^2 = .810$$
$$SE = .183$$
50 observ.

The three coefficient estimates in (10.7) are fairly collinear, and thus the t-statistics in (10.7) are low. When, for example, the value of a_2 in (10.7) was set equal to 78.36 (the estimated value) and the equation estimated by ordinary least squares, the resulting t-statistics for a_0 and a_1 were 8.69 and 14.32 respectively. The fit of equation (10.7) is quite good, with a standard error of only .183. The R-squared presented in (10.7) is the R-squared taking the dependent variable to be $PD_t - PD_{t-1}$, rather than the change in this difference. The equation explains 81 percent of the variance of the change in PD_t. As judged by the Durbin–Watson statistic, there is little evidence of serial correlation in the equation.

Other equations besides (10.7) were estimated, many of which are discussed in Fair [15], but (10.7) appeared to give the best results. Other moving averages of GAP2 were tried, for example, as well as various declining weighted averages. The use of moving averages of less than seven or eight quarters and the use of declining weighted averages lessened the ability of the equation to explain the inflation in 1969. As can be seen from Table 10–3, GAP2 was negative and large throughout 1968; and only using, for example, a four-quarter moving average did not appear to be enough to capture the demand pressure that built up during 1968 and that presumably led to the large price increases in 1969. Going from a four-quarter to an eight-quarter moving average substantially improved the ability of the equation to explain the inflation in 1969.

[6] These results differ slightly from the results presented in Table 3 of Fair [15] because of different periods of estimation used. The six strike observations were not omitted for the work in [15].

The Council of Economic Advisers trend measure of potential GNP was also tried in place of the measure constructed above, and the results were not as good. Poorer results were also obtained using a linear version of equation (10.6). The nonlinear version appeared to be necessary in order to explain the inflation in 1969. It is true, however, that even the nonlinear version underpredicted the rate of inflation in 1969 unless the equation was estimated through 1969. This is, of course, not necessarily unexpected, since one generally cannot expect an equation to extrapolate well into a period where the values of the dependent and independent variables are considerably different from what they were during the period of estimation. It can be seen from Table 10–3 that the price changes were larger and the values of the eight-quarter moving average of GAP2 smaller in 1969 than at any other time during the sample period. It is thus to some extent too early to tell how useful the price equation will be for future forecasting purposes, but it is true for the work in this study that the outside-sample forecasts in Chapter 12 underpredict the rate of inflation in 1969. This is discussed in more detail in Chapter 12 below and in Fair [15].

10.4 Predictions of Real GNP

Given values of money GNP and of PD_t, real GNP can be computed as follows. Real private output can first be computed as

$$100 \frac{GNP_t - GG_t}{PD_t},$$

where GG_t is government output in money terms. Real GNP is then merely the sum of real private output and real government output:

$$GNPR_t = 100 \frac{GNP_t - GG_t}{PD_t} + YG_t, \tag{10.8}$$

where YG_t is government output in real terms. As mentioned above, YG_t is taken to be exogenous in the model. Likewise, government output in money terms, GG_t, will be taken to be exogenous as well.

The causality in the model thus runs from predictions of GNP_t in the money GNP sector, to prediction of $GAP2_t$ in equation (10.5), to predictions PD_t in (10.7), to predictions of $GNPR_t$ in (10.8). In computing $GAP2_t$, $GNPR_t^*$ is taken to be exogenous, since it is merely a function of the exogenous variables, P_{1t}, P_{2t}, AF_t, MA_t^*, YA_t^*, MCG_t, and YG_t. Note also that $GNPR_{t-1}$ enters in the computation of $GAP2_t$. This poses no problems, however, since the value of GNPR from the previous iteration can be used.

Real GNP is by definition equal to real agricultural output plus real government output plus real private nonfarm output. The latter was denoted as Y_t in Chapter 9 and was taken to be exogenous in the employment and labor force sector. Taking real agricultural output (YA_t) to be exogenous, Y_t can be computed as:

$$Y_t = GNPR_t - YA_t - YG_t, \tag{10.9}$$

where GNPR_t is computed as above and where YG_t is exogenous. Using equation (10.9), therefore, Y_t can be computed in the price sector and fed into the employment and labor force sector.