Measuring the Performance of a Central Bank. Empirical Evidence for Germany : 1964-1989

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Introduction

Sustaining price stability is a major task of central banks in Western countries. For the Deutsche Bundesbank, it is even the main objective.[1] Its performance could in fact be measured simply by looking at the inflation rates. Since this does not take into consideration the fact, that coping with inflation might be harder in some times than in others, a measure of a central bank's performance has been developed that takes into account intertemporal variation of the circumstances under which price stability is pursued. An application of this measure to the behaviour of the Deutsche Bundesbank will show that its performance was less stable over time than could be expected by just looking at the inflation rates.

The Model

Since inflation is usually measured by an increase in the Consumer Price Index (CPI), the relevant market to look at is the one for consumer goods. Consumers and enterprises meet on the market with Walrasian market plans[2]

$$\ln D_t^W = \alpha' \cdot \ln x_t + u_t, \quad E[u_t]=0, \ Var(u_t)<\infty \tag{1a}$$

and

$$\ln S_t^W = \beta' \cdot \ln z_t + v_t, \quad E[v_t]=0; \ Var(u_t)<\infty , \tag{1b}$$

respectively. Price adjustment is incomplete, causing the economy to deviate from the Walrasian equilibrium, and is given by

$$d\ln p_t = \gamma \cdot (\ln D_t^w - \ln S_t^w), \quad \gamma>0. \tag{2}$$

The quantity traded on the market amounts to:

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[1] Cf. Deutsche Bundesbank (1985, p.9).

[2] Equations (1)-(8) follow a model of Amemiya (1974, p.759).

$$Q_t = \min(D_t^w, S_t^w). \tag{3}$$

In a regime of excess demand, supply puts through its Walrasian plan. Then, according to the price adjustment equation, the Walrasian demand plan reads

$$\ln D_t^w = \frac{1}{\gamma} d\ln p_t + \ln Q_t, \quad \forall\, t \in \{t \mid d\ln p_t > 0\}. \tag{4}$$

As effective demand D_t^e equals the quantity traded Q_t, equation (4) results in

$$\ln D_t^w = \frac{1}{\gamma} d\ln p_t + \ln D_t^e, \quad \forall\, t \in \{t \mid d\ln p_t > 0\} \tag{5}$$

and, hence, effective demand is given by

$$\ln D_t^e = -\frac{1}{\gamma} d\ln p_t + \alpha' \ln x_t + u_t, \quad \forall\, t \in \{t \mid d\ln p_t > 0\}. \tag{6}$$

Accordingly, in a regime of excess supply, effective supply reads

$$\ln S_t^e = \frac{1}{\gamma} d\ln p_t + \beta' \ln z_t + v_t, \quad \forall\, t \in \{t \mid d\ln p_t < 0\}. \tag{7}$$

Therefore, demand and supply functions are in general given by

$$\ln D_t = -\frac{1}{\gamma} d\ln p_t^+ + \alpha' \ln x_t + u_t$$

$$dp_t^+ = \begin{cases} d\ln p_t & \text{if } d\ln p_t > 0 \\ 0 & \text{otherwise} \end{cases} \tag{8a}$$

$$\ln S_t = \frac{1}{\gamma} d\ln p_t^- + \beta' \ln z_t + v_t$$

$$d\ln p_t^- = \begin{cases} d\ln p_t & \text{if } d\ln p_t < 0 \\ 0 & \text{otherwise.} \end{cases} \tag{8b}$$

Since the Walrasian plans are used to measure inflationary pressure, the arguments included in $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ should not depend on current inflation. On the demand side the explaining variables are the last period's real consumption (Q_{t-1}), and the current rates of wage (w_t) and interest ($\mathbf{i}_t$). We assume that the substitution effect of the interest rate dominates. To eliminate the influence of the level of the CPI on the nominal wage rate, it was deflated with the CPI of the last period. Past consumption was included to control for the influence of habit persistence and for a possible time trend. On the supply side, the explaining variables are production capacity, productivity and factor prices. Since a short-run supply function was used, no influence by the current interest rate is expected. Production capacity was approximated by taking the average of the last three periods' production ($\mathbf{cap}_t$). This variable should also control for a possible time trend. Labour productivity was measured by calculating the last period's real gross domestic product per working person ($\mathbf{prod}_{t-1}$). The factor prices which are included are the current nominal wage rate and the import price index of natural resources, ($\mathbf{pnr}_t$), both deflated by the last period's price level.[3]

The price movements the model generates cannot be observed directly but can be isolated from the total change of the price level. Starting with the Fisher equation

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[3] Since $\mathbf{w}_t$ and $\mathbf{pnr}_t$ are deflated by the last period's CPI and the interest rate is left uncorrected, the Walrasian market plans measure demand and supply for the case of zero inflation.

$$M_t \cdot v_t = p_t \cdot y_t^r, \tag{9}$$

we separate changes of p_t into changes due to excess supply and excess demand, p_t^k (Keynesian price movement), and into $p_t^m = p_t - p_t^k$ (monetary price movement). The Fisher equation then results in

$$d\ln M_t - d\ln p_t^m = d\ln p_t^k - d\ln v_t + d\ln y_t^r. \tag{10}$$

Consider the case of full adjustment of the price level leading to a Walrasian equilibrium of the economy. All monetary expansion that exceeds the growth rate of the equilibrium value y_t^{r*}/v_t would lead entirely to a 'monetary' price increase. Therefore, in a Walrasian equilibrium we would obtain for the left hand side of equation (10):

$$d\ln M_t - d\ln p_t^m = d\ln\left(\frac{y_t^{r*}}{v_t}\right). \tag{11}$$

Since we define

$$dp_t^m = d\ln M_t - d\ln\left(\frac{y_t^{r*}}{v_t}\right), \tag{12}$$

we obtain for the Keynesian price movement:

$$d\ln p_t^k = d\ln v_t - d\ln y_t^r + d\ln\left(\frac{y_t^{r*}}{v_t}\right). \tag{13}$$

Inserting this equation into the demand and supply functions (8a,b) leads to

$$\ln D_t = -\frac{1}{\gamma}\psi^{+} + \alpha' \ln x_t + u_t$$

$$\psi := d\ln v_t - d\ln y_t^{I} + d\ln\left(\frac{y_t^{I*}}{v_t}\right) \qquad (14a)$$

$$\psi^{+} = \begin{cases} \psi & \text{if } \psi > 0 \\ 0 & \text{otherwise} \end{cases}$$

and

$$\ln S_t = \frac{1}{\gamma}\psi^{-} + \beta' \ln z_t + v_t$$

$$\psi^{-} = \begin{cases} \psi & \text{if } \psi < 0 \\ 0 & \text{otherwise} \end{cases} \qquad (14b)$$

The system of equations (14a,b) is linear in its parameters but nonlinear in its variables. We assume the error terms to be serially and contemporaneously uncorrelated. As Amemiya (1974) shows, the equations can be consistently estimated using usual two-stage least squares. These estimates can serve as starting values for an ML-estimation, as proposed by Amemiya (1974), and give asymptotically efficient estimates. The ML-estimation was done by solving the system of equations given by the first-order conditions for an extremum of the Log-Likelihood-function.[4] The algorithm used was Broyden's secant method.[5]

Since the equilibrium path of y^{I*}/v over time cannot be observed, we let the model generate it, using an iteration procedure. For the first round, values for $d\ln(y_t^{I*}/v_t)$ $(t=1,2,...,n)$ were taken from the mean

[4] See Amemiya (1974, eqn.[9]-[13]).

[5] Contrary to Amemiya's proposal, the system of equations was solved simultaneously. As a starting value for γ, the 2SLS estimate in the demand function was chosen.

$$\frac{1}{n}\sum_{t=1}^{n} d\ln\left(\frac{Y_t^r}{v_t}\right) =: c \qquad (15)$$

to calculate a starting vector for $\mathbf{dlnp}^k$. In subsequent rounds, the model's output vector for $\mathbf{dlnp}^k$ of the proceeding round was taken as an input vector. The iteration was continued until the input vector of $\mathbf{dlnp}^k$ converged with the model's output vector.

As a measure of the central bank's performance, the following index is proposed:

$$\mathbf{perf}_t = -\frac{\mathbf{dp}_t^m}{\mathbf{dp}_t^k}. \qquad (16)$$

For values within the interval [0;1] the performance index measures the percentage of the Keynesian price movement, compensated for by the central bank. If the index is negative, the central bank's monetary expansion went in the wrong directon. If it is greater than one, the central bank over-compensated the price pressure emerging from the market of consumer goods.

Empirical Results

The model was estimated using yearly data for Germany for the period 1964-1989.[6]

The first 2SLS-estimation, done with the starting value

$$\mathbf{dln}\widehat{(y_t^*/v_t)} = c, \ t=1,2,...,n, \qquad (17)$$

yielded the following results:[7]

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[6] For details of the data used in this analysis see Appendix 2.

[7] The t-values, given in parentheses, were calculated using the large-sample properties of the 2SLS-estimators.

Demand: $\ln Q_t = -6.169 \cdot 10^{-1} \text{dlnp}_t^{k,+} + 8.009 \cdot 10^{-1} \ln Q_{t-1}$
(-0.945) (11.693)

$+4.715 \cdot 10^{-2} \ln i_t + 1.866 \cdot 10^{-1} \ln w_t$
(0.336) (2.089)

$+1.245$
(2.199)

$$\text{with} \quad \text{dlnp}_t^{k,+} = \begin{cases} \text{dlnp}_t^k & \text{if } \text{dlnp}_t^k > 0 \\ 0 & \text{otherwise} \end{cases}$$

R^2: 0.992; $\bar{R}^2$: 0.990; h: -0.371;[8] RSS: $1.073 \cdot 10^{-2}$;

Supply: $\ln Q_t = 2.084 \cdot 10^{-1} \text{dlnp}_t^{k,-} - 8.873 \cdot 10^{-3} \ln w_t$
(0.622) (-0.056)

$-7.614 \cdot 10^{-4} \ln pnr_t + 3.940 \cdot 10^{-1} \ln cap_t$
(-1.374) (1.235)

$+7.260 \cdot 10^{-1} \ln prod_{t-1} + 8.123 \cdot 10^{-1}$
(2.948) (0.725)

$$\text{with} \quad \text{dlnp}_t^{k,-} = \begin{cases} \text{dlnp}_t^k & \text{if } \text{dlnp}_t^k < 0 \\ 0 & \text{otherwise} \end{cases}$$

R^2: 0.994; $\bar{R}^2$: 0.991; DW: 1.474; RSS: $8.640 \cdot 10{-3}$;

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8 Statistic to test first-order serial correlation of residuals with a lagged dependent variable as a regressor. See Johnston (1984, p.318).

$r(u_t, v_t)$: -0.336.[9]

Since this estimation was done with an approximated vector for $dlnp^k$, the test statistic is not reliable. Nevertheless, the goodness of fit is surprising, and it is interesting to note that the parameters of the nonconstant regressors, except the one for the interest rate, have the expected sign.

Using the 2SLS estimates as starting values for a ML-estimation, we obtain the following results:[10]

$$\text{Demand:} \quad lnQ_t = \underset{(8.374)}{-(1/3.191)}\, dlnp_t^{k,+} \underset{(21.764)}{+7.959\cdot 10^{-1}}\, lnQ_{t-1}$$

$$\underset{(-0.968)}{-1.668\cdot 10^{-2}}\, lni_t \underset{(4.245)}{+1.976\cdot 10^{-1}}\, lnw_t$$

$$\underset{(5.513)}{+1.394}$$

RSS: $3.135\cdot 10^{-3}$.

9 A likelihood ratio test, based on this correlation coefficient, does not support the H1-hypothesis of contemporaneous correlation at the 0.05 significance level. For the test see Hogg and Craig (1970, pp.339-42).

10 The t-values are given for γ, not for $-1/\gamma$ or $1/\gamma$, respectively.

$$\text{Supply:}\quad \ln Q_t = \underset{(8.374)}{(1/3.191)}\, d\ln p_t^{k,-} \underset{(-0.567)}{-5.173\cdot 10^{-2}} \ln w_t$$

$$\underset{(-2.467)}{-9.047\cdot 10^{-4}} \ln pnr_t \underset{(2.173)}{+4.751\cdot 10^{-1}} \ln cap_t$$

$$\underset{(2.974)}{+6.793\cdot 10^{-1}} \ln prod_{t-1} \underset{(0.777)}{+5.073\cdot 10^{-1}}$$

RSS: $1.167\cdot 10^{-2}$.

To calculate the output values of the model for $d\ln p^k$, the estimated supply function was subtracted from the estimated demand function leading to

$$\ln\hat{D}_t - \ln\hat{S}_t = -\frac{1}{\hat{\gamma}}\, d\ln p_t^k + \hat{\alpha}'\ln x_t - \hat{\beta}' z_t. \tag{18}$$

The correct vector of $d\ln p^k$ can be found by eliminating the difference on the left-hand side by iteration. Hence, for the next estimation, the input vector of $d\ln p^k$ was calculated by

$$\hat{\gamma}\,(\hat{\alpha}'\ln x_t - \hat{\beta}'\ln z_t). \tag{19}$$

The procedure was repeated until the input and output values for $d\ln p^k$ converged.[11] The ML-results of the last round are given by:[12]

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[11] Except for the first round, the estimated parameters of the proceeding ML-estimation were used as starting values for the ML-estimation.

[12] Again, the t-values are that for γ, not for $-1/\gamma$ or $1/\gamma$, respectively.

Demand: $\ln Q_t = -1/(2.513\cdot10^{-1})\,\mathrm{dlnp}_t^{k,+} + 2.186\cdot10^{-1}\ln Q_{t-1}$
(10.552) (3.427)

$-1.596\cdot10^{-1}\ln i_t + 9.864\cdot10^{-1} w_t$
(-10.051) (11.580)

$+5.419$
(12.488)

R^2: 0.999; $\bar{R}^2$: 0.998; h: 0.830; RSS: 2.651·10-3;[13]

Supply: $\ln Q_t = 1/(2.513\cdot10^{-1})\,\mathrm{dlnp}_t^{k,-} - 5.469\cdot10^{-1}\ln w_t$
(10.552) (-7.505)

$-9.064\cdot10^{-4}\ln pnr_t + 7.792\cdot10^{-1}\ln cap_t$
(-5.112) (6.760)

$+5.714\cdot10^{-1}\ln prod_{t-1} - 9.260\cdot10^{-1}$
(5.158) (-2.449)

R^2: 0.993; $\bar{R}^2$: 0.991; *DW*: 1.744; *RSS*: 2.635·10-3;
$r(u_t,v_t)$: 0.251.

The H0-hypothesis of stochastic independence of the error terms u and v cannot be rejected even at the 10% level. The test statistic also fails to indicate that first-order serial correlation is present in any equation.

As Figure 1 shows, among the 26 periods under consideration there are only 12 with excess demand. The Deutsche Bundesbank

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13 The R^2 values, the h-statistic, the DW-statistic and the coefficient of contemporaneous correlation of the residuals were calculated from a 2SLS estimation, using the last output vector of **dlnp**^{k} as input vector.

always succeeded in preventing deflation by means of monetary expansion, except for the year 1986. Although in this year the monetary price movement worked against the Keynesian downward

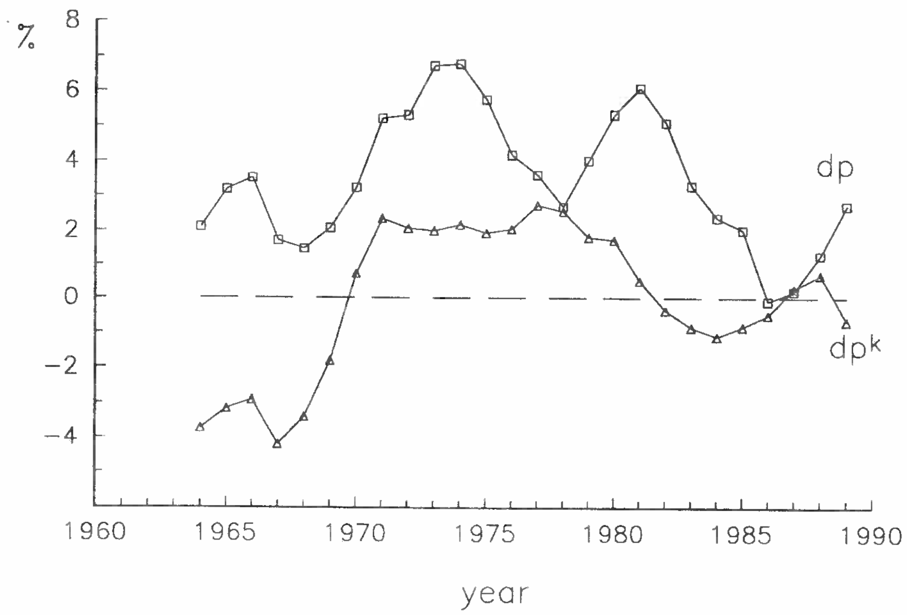

Figure 1

pressure, it was dominated by the latter. In the 1982-1985 period, the Bundesbank expanded money much more than necessary to fight deflation. Figure 2 shows that its performance was much better in the deflationary 1964-1969 period, a time when monetaristic ideas had not yet had an influence on its monetary policy.

The periods in which inflationary pressure emerged from the consumer goods market were mainly in the seventies. In this decade, the Bundesbank's monetary expansion never opposed the Keynesian price movement. At the beginning of the seventies, there was a rapidly growing demand causing inflationary pressure before, in 1973/74 and 1978/79, supply shocks occurred due to increases in oil prices. The oil price shocks did not cause a significantly higher Keynesian price movement than the boom period of 1971/72 and never exceeded 2.6%.[14] As Figure 2 shows, the Bundesbank performed fairly well during the first supply shock and handled the second one even better.

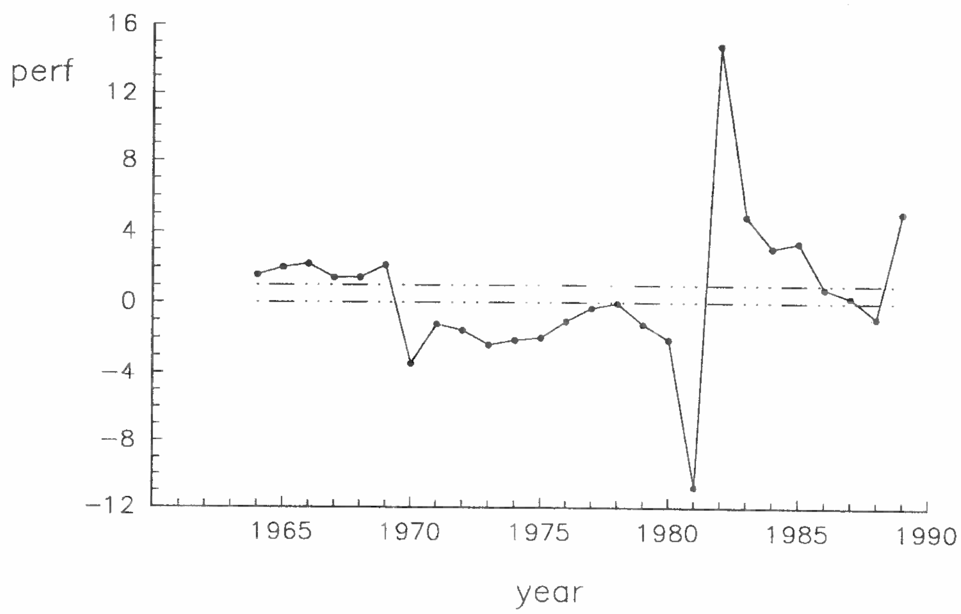

Figure 2

The Bundesbank performed badly in the 1981/82 period. During this period, there was a turning point in the Keynesian price movement, which dropped from about 2% and more in the seventies to about -1% in 1983-1985. This change was not realized by the Bundesbank until 1984. In this year it gave up its concept of an 'unvermeidliche Preissteigerungsrate' ('unavoidable inflation rate') when fixing monetary expansion for 1985.[15] Figure 2 indicates that the Bundesbank missed this turning point and

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[14] See Table a1-1 in the Appendix.

[15] This conception was used since the Bundesbank fixed the monetary expansion for the first time for the year 1975. [Cf. Deutsche Bundesbank (1985,pp.90-1)]. For the seventies, it may coincide with what we measured as Keynesian inflationary pressure.

clung too long to the 'unavoidable inflation rate' it was used to in the seventies.

Conclusion

A model for measuring the performance of a central bank was introduced and applied to Germany. The analysis showed that the second half of the sixties and the first half of the eighties were times of excess supply on the market for consumer goods, leading to a downward pressure on the price level. The seventies were characterized by excess demand although the upward price pressure emerging from it was never higher than 2.8%.

The performance of the Deutsche Bundesbank was not so stable over time as it seems when looking at the actual inflation rates, although it performed well during both oil price shocks. The worst mistake it made was to miss the turning point of the Keynesian price movement in the period 1981/82. The Bundesbank was used to a Keynesian inflationary pressure of about 2% and more in the seventies which it yielded to by labeling it 'unavoidable'. When this pressure vanished, it took the Bundesbank too long to realize this and to adjust its monetary growth rate.

Appendix 1

Table a1-1 shows the actual inflation rate, its components and the performance index **perf**.

year	**dp**	dp^m	dp^k	**perf**
1964	2.10	5.83	-3.73	1.56
1965	3.18	6.34	-3.16	2.01
1966	3.52	6.43	-2.91	2.21
1967	1.71	5.91	-4.20	1.41
1968	1.48	4.88	-3.41	1.43
1969	2.07	3.90	-1.83	2.13
1970	3.23	2.50	0.72	-3.47
1971	5.22	2.87	2.35	-1.22
1972	5.32	3.25	2.07	-1.57

1973	6.73	4.74	1.99	-2.38
1974	6.78	4.60	2.17	-2.12

perf (cont.):

year	**dp**	**dp^m**	**dp^k**	**perf**
1975	5.76	3.83	1.93	-1.99
1976	4.18	2.13	2.05	-1.04
1977	3.61	0.87	2.73	-0.32
1978	2.69	0.13	2.56	-0.05
1979	4.03	2.22	1.81	-1.23
1980	5.33	3.60	1.73	-2.08
1981	6.09	5.57	0.52	-10.78
1982	5.10	5.46	-0.37	14.83
1983	3.29	4.15	-0.86	4.83
1984	2.37	3.50	-1.12	3.11
1985	2.02	2.86	-0.84	3.40
1986	-0.10	0.40	-0.50	0.80
1987	0.20	-0.08	0.28	0.29
1988	1.29	0.59	0.70	-0.85
1989	2.72	3.40	-0.67	5.05

Table a1-1

Table a1-2 displays the observed consumption, the consumption 'predicted' by the model and the percentage deviation of the two values as well as the Walrasian market plan as calculated by the model.

Demand:[16]

year	Q_t	$\hat{Q}_t$	$\frac{Q_t - \hat{Q}_t}{Q_t} \cdot 100$	D_t^w
1964	448.22	444.32	0.87	444.32
1965	479.02	470.48	1.78	470.48
1966	493.66	496.51	-0.58	496.51
1967	498.87	500.14	-0.26	500.14
1968	522.51	527.84	-1.02	527.84
1969	564.14	569.05	-0.87	569.05
1970	606.81	613.17	-1.05	631.18
1971	638.14	632.01	0.96	694.33
1972	666.60	664.90	0.25	722.51

16 Values are given in billions of Deutsche Mark in 1980 prices.

1973	686.98	687.83	-0.12	745.80
1974	691.49	697.56	-0.88	762.56
1975	713.88	723.58	-1.36	782.21

Demand (cont.):

year	Q_t	$\hat{Q}_t$	$\frac{Q_t - \hat{Q}_t}{Q_t} \cdot 100$	D_t^w
1976	740.35	737.18	0.43	800.62
1977	771.83	769.91	0.25	857.19
1978	801.45	802.77	-0.17	887.00
1979	830.41	818.00	1.49	878.76
1980	840.78	825.05	1.87	884.88
1981	836.38	829.09	0.87	848.91
1982	825.23	843.42	-2.20	843.42
1983	839.60	841.23	-0.19	841.23
1984	852.29	842.40	1.16	842.40
1985	863.98	867.21	-0.37	867.21
1986	893.39	902.24	-0.99	902.24
1987	922.60	930.60	-0.87	938.92
1988	947.48	939.26	0.87	964.19
1989	963.85	964.00	-0.02	964.00

Table a1-2a

Supply:

year	Q_t	$\hat{Q}_t$	$\frac{Q_t - \hat{Q}_t}{Q_t} \cdot 100$	S_t^w
1964	448.22	444.48	0.84	515.41
1965	479.02	470.66	1.75	533.56
1966	493.66	496.57	-0.59	557.53
1967	498.87	499.91	-0.21	591.16
1968	522.51	527.28	-0.91	604.44
1969	564.14	568.41	-0.76	611.92
1970	606.81	613.29	-1.07	613.29
1971	638.14	632.36	0.91	632.36
1972	666.60	665.42	0.18	665.42
1973	686.98	689.00	-0.29	689.00
1974	691.49	699.37	-1.14	699.37
1975	713.88	724.42	-1.48	724.42
1976	740.35	737.89	0.33	737.89
1977	771.83	768.85	0.39	768.85
1978	801.45	801.16	0.04	801.16
1979	830.41	817.79	1.52	817.79
1980	840.78	825.97	1.76	825.97
1981	836.38	831.61	0.57	831.61

1982	825.23	845.08	-2.40	855.88
1983	839.60	841.82	-0.26	870.49
1984	852.29	842.48	1.15	880.95

Supply (cont.):

year	Q_t	$\hat{Q}_t$	$\frac{Q_t - \hat{Q}_t}{Q_t} \cdot 100$	s_t^w
1985	863.98	866.17	-0.25	896.80
1986	893.39	900.03	-0.74	920.55
1987	922.60	928.50	-0.64	928.50
1988	947.48	937.76	1.03	937.76
1989	963.85	962.18	0.17	990.18

Table a1-2b

Appendix 2

List of variables:

cap_t	mean of last three periods' private consumption in 1980 prices
i_t	long-term interest rate
M_t	monetary aggregate M3
p_t	Consumer Price Index
pnr_t	price index of imported natural ressources
$prod_t$	productivity (gross domestic product per working person in 1980 prices)
Q_t	private consumption in 1980 prices
w_t	personal income per employee in current prices
y_t^r	gross domestic product in 1980 prices.[17]

[17] The interest rate data were reported by the Deutsche Bundesbank on request. All other data were taken from the Jahresgutachten 1990/91 des Sachverständigenrates zur Begutachtung der gesamtwirtschaftlichen Entwicklung (Deutscher Bundestag, Drucksache 11/8472).

References

Amemiya, T. (1974) 'A Note on a Fair and Jaffee Model', Econometrica 42, 759-62.

Amemiya, T. (1985) Advanced Econometrics. Oxford.

Deutsche Bundesbank (1985) Die Deutsche Bundesbank. Geldpolitische Aufgaben und Instrumente. Sonderdrucke der Deutschen Bundesbank Nr.7, 3.Aufl.

Johnston, J. (1984) Econometric Methods, 3rd ed. Auckland.

Hogg, R.V. and A.T. Craig (1970) Introduction to Mathematical Statistics, 3rd ed. New York and London.