CLASSIFYING U.S. BUSINESS CYCLES 1948 TO 1997 –
MEYER/WEINBERG REVISITED[1]

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U.S. business cycle, 4-phase scheme, discriminant analysis.

Introduction

The decomposition of the business cycle into different but related stages – "cyclical taxonomy" - serves two purposes.[3] For theory, it offers a deeper understanding of its subject. To describe "What happens during business cycles" (Mitchell 1951) may help to determine the "stylised facts" to be explained and the levers theory should make use of. For policy, it should help to identify pathological states of the economy directly and forecasting, if relationships between stages are high enough and sufficiently stable. Hence the literature on cycle classification dates back to the 19th century and the 20th century literature includes the seminal works by *Haberler* (1936) and *Burns/Mitchell* (1947). While Haberler's summing up of business cycle theories propagated the now famous 4-phase scheme, Burns/Mitchell found a host of empirical evidence for a 9-stage scheme. Both schemes had a theoretic orientation, although rather different ones; forecasting purposes played no great role in it. The advent of macroeconomics on a

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grand scale after WWII greatly reduced the interest in this field. However the Burns/Mitchell approach continued to be used by the *National Bureau of Economic Research* (NBER) in its dating and analysis of business cycles and growth cycles (Zarnowitz 1992, 316ff.). A popular 2-phase scheme of cyclical classification is applied to single variables such as GDP or industrial production to determine upswings or downswings.

As with biology or geology, taxonomy serves only as groundwork for cognitive analysis, as Mitchell and Burns, for example, were well aware. Even 40 years later, cyclical taxonomy is still criticised for being only phenomenally oriented, presenting "associations" and not "causes" (Auerbach 1986). The recently heightened interest in and discussion of "stylised facts" of the business cycle should have qualified this criticism.

In 1975, *John Meyer* and *Daniel Weinberg(M/W)* (1975a,b, 1976) presented a new scheme to classify U.S. business cycles. Based on modern cyclical experiences and theory, they had increased the number of cycle stages from 2 to 4 and developed a kind of reference cycle. The classifying factors were quantified with the help of multivariate discriminant analysis. The scheme was first tested for the U.S., but proved also to be successful for West Germany (M/W 1975b, Heilemann, Münch 1999). Surprisingly, despite these results and the numerous analytical possibilities that M/W's approach offers, it remained unnoticed.[4] In a report about their 5-stage classification scheme,[5] *Eckstein/Sinai* (1986) don't even mention it.

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3 For a methodical classification of cyclical taxonomy with multivariate discriminant analysis, see Heilemann 2000.

4 As Victor Zarnowitz revealed in a personal communication in January 2002, M/W's approach was discussed at NBER – Meyer was then president of NBER (see also M/W 1976). A pivotal role for that might have been played by M/W's by and large ignorance of the distinction between business cycles and growth cycles. Other factors might have included the selection of the classifying variables.

5 The work on the scheme, established in 1986 for 1945-4 to 1982-4, had started in the mid 1970s. Its dating of the cycles followed the NBER chronic of business cycles, but with its distinction of five stages, the authors tried to pay more tribute to the role of finance market conditions ("credit crunch", "reliquidation") during recession and recovery.

The starting point for M/W's classification was the NBER's *business cycle* dating, a 2-stage cycle scheme which, with the help of 20 variables, they split into a 4-phase scheme, including "Recession", "Recovery", "Demand-pull" and "Stagflation". The variables and their weights they used to separate the stages were selected by multivariate discriminant analysis. The resulting scheme (stages and variables) was successfully tested, not only for the then five U.S. post-WWII cycles, but also for pre-WWII cycles. In various updates and extensions by M/W and the present authors (for the U.S.: Heilemann 1982; for Germany: Heilemann, Münch 1999, 2001), the scheme proved to be rather successful, even though in the German case the sample period had almost doubled.

This all suggests a re-examination of the M/W scheme to classify U.S. business cycles. The present paper does so for the period 1948 to 1997. Although the scheme and some of its classification performances appear remarkably stable, a number of tests also point towards important changes in the nature and causes of U.S. post-WWII cycles – or of M/W's "modern view" of the cycle. It will become quite clear that the variables used for classification will need some reworking in the future. M/W's idea of the modern cycle was dominated by the growth/inflation experience, or trade-off, as perceived in the early 1970s. In their writing, M/W do not reveal what prevented them from integrating their view in a broader set of variables. While it is beyond the possibilities of this paper to establish a new set of classifying variables, or even a new scheme, the results lead to some suggestions.

The next section (I) reports on M/W's 4-phase classification scheme, makes some remarks on the data employed and then presents the results of our reproduction of the M/W's results up to 1973 (a short description of multivariate discriminant analysis can be found in the appendix). Section II reports on the extension of M/W's classification up to 1997 and discusses some implications of the classifying functions. In the light of the present results, the final section (III) reflects on the methodical efficiency of reductionistic approaches to investigate macroeconomic fluctuations and makes some suggestions for future research.

I. Re-examining Meyer/Weinberg's results

Starting from the NBER *business cycle* dating, M/W suggest a 4-phase cycle scheme, defined as follows (M/W 1975a, p. 172f.): (1) *Recession*. A period of some duration in which total aggregate activity actually declines somewhat from previous peak levels and is reasonably widely diffused throughout the economy. (2) *Recovery*. The early expansion out of a recession and a state of economic affairs in which everything is "going well" – unemployment is declining, prices are relatively stable, productivity is rising and total output is expanding. (3) *Demand-Pull Inflation*. The classic inflationary situation, in which "too much money chases too few goods". The forces of recovery are somehow allowed to achieve too much force or pull, with production forced up to capacity constraints, prices rising, rates of productivity improvement declining etc. (4) *Stagflation*. A situation of stagnation at a high level of activity mixed with price inflation. The strains of demand-pull perhaps recede and total monetary expansion diminishes. However, prices and wages continue to increase; perhaps because of catch-up effects due to sectoral imbalances created during the preceding demand-pull inflation, or because productivity does not improve enough to stabilise wage cost.

M/W's scheme differs from older 4-phase schemes (e.g. *Haberler's*) by, firstly, its new interpretation of the upper turning point phase as "Demand-Pull Inflation" and the downswing phase as "Stagflation"; secondly, by concentrating more or less on two groups of variables: "economic activity" and "inflation". Although the classification is supposed to describe post-WWII experience, the names and the role played by inflation for "Demand-Pull" and "Stagflation" – and hence the terms – were, as we know now, typical only for the late 1960s and early 1970s.

As a first or *a priori* classification, M/W started with the 2-stage NBER classification of the period February 1947 to September 1973. The new stages, "Demand-Pull" and "Stagflation", were separated – from Upswing and Recession, respectively – by "common economic sense" augmented by general knowledge of "recent business cycle

Table 1

Classification of US business cycles into a four-stage scheme
1948-5 to 1997-12

	Cycle[1]	Starting months of …			
		Recovery	Demand-Pull	Stagflation	Recession
1	1948-5 to 1949-10 (18)	…	…	1948-5 (7)	1948-12 (11)
2	1949-11 to 1954-7 (57)	1949-11 (8)	1950-7 (6)	1951-1 (34)	1953-11 (9)
3	1954-8 to 1958-4 (45)	1954-8 (7)	1955-3 (30)	-	1957-9 (8)
4	1958-5 to 1961-1 (33)	1958-5 (25)	-	-	1960-6 (8)
5	1961-2 to 1970-11 (118)	1961-2 (51)	1965-5 (31)	1967-12 (25)	1970-1 (11)
6	1970-12 to 1975-3 (52)	1970-12 (25)	1973-1 (21)	-	1974-10 (6)
7	1975-4 to 1980-9 (66)	1975-4 (39)	1978-7 (12)	-	1979-7 (15)
8	1980-10 to 1982-12 (27)	1980-10 (6)	1981-4 (6)	-	1981-10 (15)
9	1983-1 to 1991-12 (108)	1983-1 (15)	1984-4 (43)	1987-11 (36)	1990-11 (13)
10	1991-12 to 1997-12 (73)	1991-12 (73)	…	…	…
	All				
	1948-5 to 1997-12 (596)	249	149	102	96

Sources: Meyer/Weinberg (1948-5 to 1973-9) and authors' computations (1973-10 to 1997-12). – Cycle/ phase length in parentheses.

history" (M/W 1975a, p. 175)[6]. Following an *a priori* classification of the sample period, this period was then classified with the help of Bayesian multivariate discriminant functions including 20 variables. Boundary months between cyclical stages were – in an iterative way – re-assigned according to the classifications of the discriminant analysis. The resulting dating of the first six post-WWII cycles and their stages are shown in Table 1. The variables used in the initial discriminant analysis were

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6 For good overviews over the various cycles, see e.g., Glasner (ed.) 1997, Zarnowitz 1992, pp. 20ff.

Table 2

Average values of classifying variables
1948-5 to 1997-12

Variable		Stage[1] Recovery	Demand-Pull	Stagflation	Recession	All
Real GNP[2]	a	4.20	5.21	4.94	-0.09	3.95
	b	3.52	4.30	3.38	-0.28	3.08
	c	3.33	4.04	3.38	-0.82	2.95
	d	3.83	4.51	4.39	-0.31	3.43
Unemployment rate[2]	a	5.76	4.18	3.29	5.47	4.79
	b	6.91	6.79	5.43	7.63	6.80
	c	6.68	7.02	5.43	8.16	6.74
	d	6.37	5.33	4.04	6.56	5.74
Index of unit labor cost, private economy[2]	a	-0.49	2.14	4.98	4.03	2.04
	b	1.32	1.80	2.32	5.76	2.26
	c	-0.49	0.68	2.32	3.92	0.87
	d	0.48	2.49	4.04	5.42	2.39
Govt. surplus or deficit as per cent of GNP[2]	a	-0.22	-0.19	0.15	-0.28	-0.14
	b	-2.90	-2.90	-2.36	-2.87	-2.83
	c	-2.84	-3.44	-2.36	-3.53	-2.99
	d	-1.66	-1.34	-0.73	-1.58	-1.41
GNP price deflator[2]	a	2.06	3.28	4.02	2.20	2.81
	b	4.07	4.46	3.66	6.35	4.46
	c	2.90	3.71	3.66	5.15	3.53
	d	3.14	4.13	3.89	4.58	3.75
Prime rate[3]	a	0.07	1.73	1.20	-1.00	0.56
	b	0.50	0.39	0.30	-1.55	0.12
	c	0.59	-0.15	0.30	-2.88	-0.10
	d	0.30	1.19	0.88	-1.60	0.32
Gross govt. expenditures[2]	a	2.89	4.38	23.21	5.13	8.00
	b	4.30	8.76	3.11	10.11	6.05
	c	2.58	8.53	3.11	8.81	4.92
	d	3.64	6.17	16.12	7.82	7.08
Money supply M2[2]	a	7.88	6.37	5.68	3.60	6.37
	b	6.57	8.08	5.02	7.11	6.79
	c	4.49	8.19	5.02	6.66	5.75
	d	7.18	7.05	5.45	5.32	6.55
Money supply M1[2]	a	3.57	3.65	4.62	0.76	3.38
	b	5.60	9.93	3.00	6.18	6.32
	c	5.26	10.41	3.00	5.95	6.18
	d	4.65	6.35	4.05	3.40	4.77
Net exports as per cent of GNP	a	0.23	0.41	0.54	0.83	0.43
	b	-0.24	-0.54	-0.50	-0.01	-0.31
	c	-0.33	-0.66	-0.50	-0.02	-0.40
	d	-0.02	-0.01	0.17	0.41	0.08
Wholesale price index, industrial[2] commodities only	a	0.87	3.50	3.56	0.96	2.12
	b	3.64	2.97	4.03	7.67	4.18
	c	2.17	1.44	4.03	2.99	2.43
	d	2.35	4.42	3.73	5.43	3.60
Compensation per man-hour[2]	a	4.59	5.96	5.67	2.83	4.89
	b	5.19	4.94	5.09	4.91	5.08
	c	5.30	5.01	5.09	5.09	5.17
	d	4.91	5.42	5.46	3.89	4.97

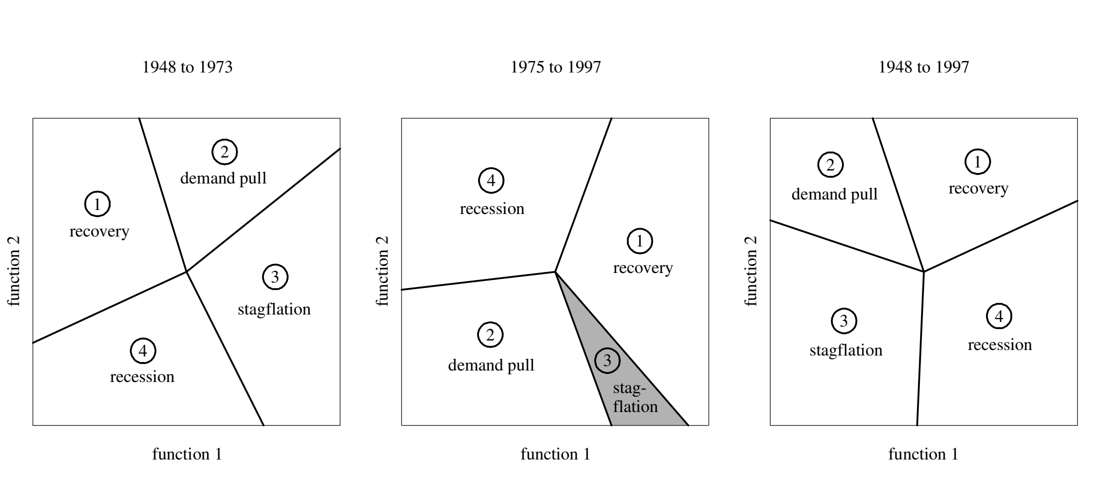
Table 2, continued

Variable		Stage[1] Recovery	Demand-Pull	Stagflation	Recession	All
Average yields on corporate bonds (Moody's)[3]	a	0.12	0.99	0.68	-0.60	0.35
	b	-0.01	0.09	-0.25	-0.21	-0.05
	c	-0.03	-0.01	-0.25	-1.32	-0.24
	d	0.05	0.67	0.35	-0.45	0.18
Consumer price index[2]	a	2.12	4.07	2.90	1.28	2.65
	b	4.37	5.40	4.96	6.57	5.03
	c	3.34	3.70	4.96	3.55	3.73
	d	3.32	5.18	3.63	4.07	3.96
Consumer price index, food only[2]	a	1.05	2.22	5.53	1.81	2.43
	b	3.83	5.51	4.98	6.27	4.74
	c	2.88	4.12	4.98	4.71	3.79
	d	2.54	4.82	5.34	4.43	3.89
Output per man-hour[2]	a	1.40	0.76	0.57	0.64	0.95
	b	0.78	0.37	0.37	0.08	0.52
	c	0.76	0.45	0.37	0.22	0.54
	d	1.07	0.48	0.50	0.40	0.72
N.Y. Stock Exchange composite price index[2]	a	1.23	0.35	0.13	0.34	0.63
	b	0.97	0.88	0.26	1.57	0.95
	c	1.12	0.97	0.26	1.51	0.99
	d	1.09	0.24	0.17	1.11	0.72
Consumer price index, all commodities exept food[2]	a	1.89	1.92	4.52	3.45	2.70
	b	4.80	4.86	4.44	9.48	5.50
	c	3.71	4.12	4.44	7.28	4.42
	d	3.44	3.47	4.49	6.67	4.15
Wholesale price index[2]	a	0.52	2.99	4.02	1.24	2.00
	b	3.48	2.82	4.03	7.24	4.00
	c	2.14	1.32	4.03	3.76	2.50
	d	2.10	3.98	4.02	5.15	3.39

Authors' computations. – 1) a: Results for period 1948-5 to 1973-9, b: 1975-4 to 1997-12, c: 1980-10 to 1997-12, d: 1948-5 to 1997-12. – 2) Changes are against previous year. – 3) Per cent change per month.

those used by the NBER in its cycle chronic, those suggested by policy and historical considerations, those that figured prominently in macroeconomic models or those that had been singled out as particularly sensitive cyclical indicators (M/W 1975a, p. 176). However, whilst the NBER business cycle dating is based on the levels of variables (see Zarnowitz 1992, p. 284), classification procedures like linear discriminant analysis have to be based on more or less "stationary" data to deliver reasonable results. Therefore, all variables with an underlying trend have to be transformed into changes or differences. The average values in the four stages "more or less confirm prior expectations in different cyclical stages" (M/W 1975a, p. 178, see also Table 2, line a).

Figure 1



Stability of the Meyer/Weinberg-Scheme for the US Business Cycle
1948 to 1997

Authors' computations.

However, M/W did not reveal the complete set of variables they had tested and the criteria for inclusion in their discriminant functions. It is at least surprising that there are several indicators of real activity and inflation, while there are hardly any of disaggregated demand.

Eigenvalues and cumulative proportions of “explained” dispersion led M/W to find two canonical discriminant functions as sufficient and as allowing them a straightforward interpretation of results. The first discriminant function differentiates by unemployment, interest rate changes, productivity and various price deflators, thus separating recessions and recoveries from the two “inflation” periods. “Specifically, high unemployment rates, good productivity gains, negative changes in corporate bond rates, and small to negative price changes will yield a high negative score on this index; opposite conditions will register positively” (M/W 1975a). The second function apparently adds only a little to this differentiation. Mainly the course of interest rates helps somewhat in separating the “growth” stages (Recovery, Demand-Pull) from the two “no-growth” periods (1948 to 1973, s. Figure 1).

Table 3

Estimation results for the standardized canonical discriminant functions[1]
1948-5 to 1997-12

Variable		Coefficients of function[1] 1	2	3	F-Value to enter
Unemployment rate	a	-1.01	-0.26	0.33	292.7
	b	0.13	0.78	1.56	24.4
	c	1.24	-0.62	1.88	30.0
	d	1.05	0.69	0.07	94.8
Real GNP[2]	a	-0.44	0.57	0.45	54.4
	b	1.08	-0.57	0.58	77.2
	c	-0.11	1.13	0.46	78.6
	d	-0.42	0.37	-0.30	116.6
Index of unit labor cost, private economy[2]	a	0.03	-0.34	-0.24	64.4
	b	0.17	-0.25	0.60	15.8
	c	-0.55	0.39	0.21	21.0
	d	-0.18	-0.40	0.28	54.9
Govt. surplus or deficit as per cent of GNP[2]	a	0.18	-0.12	0.63	3.6
	b	0.10	0.48	1.73	1.8
	c	0.78	-0.43	2.08	8.2
	d	0.62	0.00	-0.06	7.7
GNP price deflator[2]	a	-0.54	0.90	0.12	20.6
	b	3.30	-1.92	-1.26	12.3
	c	-0.58	2.48	-1.24	11.1
	d	-0.47	0.23	0.19	10.4
Prime rate[3]	a	0.08	-0.02	0.02	12.4
	b	0.17	0.07	0.06	2.5
	c	-0.03	0.10	0.20	6.3
	d	-0.04	0.11	-0.14	12.0
Gross govt. expenditures[2]	a	0.18	-0.21	0.41	31.8
	b	0.23	-0.32	0.85	32.9
	c	-0.29	-0.02	0.96	31.2
	d	-0.22	-0.11	-0.15	28.9
Money supply M2[2]	a	-0.05	0.81	0.26	33.1
	b	0.01	0.18	-0.18	6.4
	c	-0.13	0.27	-0.94	19.9
	d	-0.04	0.27	-0.01	14.1
Money supply M1[2]	a	0.29	-0.64	0.21	30.5
	b	-0.93	-0.15	0.80	23.0
	c	-0.83	-0.95	0.93	19.1
	d	-0.05	-0.06	0.57	13.8
Net exports as per cent of GNP	a	0.19	0.33	-0.33	12.2
	b	-0.24	1.05	0.21	52.7
	c	0.87	-0.52	-0.01	74.9
	d	0.19	0.01	0.45	14.0
Wholesale price index, industrial[2] commodities only	a	0.80	-1.19	0.57	19.0
	b	0.52	0.44	0.61	10.6
	c	0.17	0.57	0.11	4.7
	d	-0.07	0.01	0.26	10.7
Compensation per man-hour[2]	a	0.23	0.36	0.23	23.8
	b	3.34	-0.12	0.77	22.0
	c	1.07	2.47	-0.16	24.9
	d	-0.20	0.02	-0.16	20.6

Table 3, continued

Variable		Coefficients of function[1] 1	2	3	F-Value to enter
Average yields on corporate bonds (Moody's)[2]	a	0.09	0.26	-0.04	10.5
	b	-0.01	-0.02	0.03	0.2
	c	-0.16	-0.07	0.09	1.9
	d	-0.07	0.09	0.06	5.5
Consumer price index[2]	a	0.22	0.17	-0.55	16.9
	b	0.76	0.54	-0.69	6.2
	c	1.15	1.02	-0.29	8.9
	d	0.04	0.10	0.68	11.4
Consumer price index, food only[2]	a	0.62	-0.41	0.39	21.6
	b	-1.12	-0.62	0.30	11.1
	c	-1.34	-0.36	-0.16	15.0
	d	-0.68	-0.09	-0.10	16.3
Output per man-hour[2]	a	0.00	0.06	0.04	9.8
	b	0.09	-0.12	-0.06	10.0
	c	-0.11	0.20	0.14	4.8
	d	0.00	0.12	-0.33	16.3
N.Y. Stock Exchange composite price index[2]	a	0.07	0.12	0.15	2.5
	b	0.06	0.03	0.14	1.1
	c	0.02	0.06	0.17	0.9
	d	0.02	0.02	-0.03	3.5
Consumer price index, all commodities[2] exept food	a	0.11	-0.74	1.06	44.9
	b	-0.77	1.05	-0.25	32.5
	c	0.85	-0.62	-0.36	16.3
	d	0.47	-1.05	-1.26	32.1
Wholesale price index[2]	a	-0.69	1.19	-1.40	14.8
	b	-0.05	-0.10	0.05	10.9
	c	0.18	-0.42	0.08	6.5
	d	0.77	0.60	0.23	11.5

Eigenvalues

Function		Eigen-value	% of variance	cumu-lative %	canonical corre-lation	after function	Wilks' λ	χ^2	df	Signifi-cance
	1	4.5	68.4	68.4	0.9	1	0.0	910.5	57	0.00
a	2	1.4	20.6	89.0	0.8	2	0.2	410.9	36	0.00
	3	0.7	11.0	100.0	0.6		0.6	159.9	17	0.00
	1	3.0	49.7	49.7	0.9	1	0.0	797.8	57	0.00
b	2	2.4	40.8	90.5	0.8	2	0.2	438.8	36	0.00
	3	0.6	9.5	100.0	0.6		0.6	117.5	17	0.00
	1	5.7	58.3	58.3	0.9	1	0.0	778.3	57	0.00
c	2	3.1	31.7	89.9	0.9	2	0.1	408.1	36	0.00
	3	1.0	10.1	100.0	0.7		0.5	133.6	17	0.00
	1	1.4	57.3	57.3	0.8	1	0.2	967.7	57	0.00
d	2	0.8	34.5	91.8	0.7	2	0.5	459.8	36	0.00
	3	0.2	8.2	100.0	0.4		0.8	105.5	17	0.00

Authors' computations. Eigenvalue: eigenvalues of the discriminant functions in declining order. % of variance: % importance of the discriminant functions. cum %: cumulative importance in relative terms. df: degrees of freedom. For a detailed description of the statistics see Brosius (1989). – 1) a: Results for period 1948-5 to 1973-9, b: 1975-4 to 1997-12, c: 1980-10 to 1997-12, d: 1948-5 to 1997-12. – 2) Changes against previous year. – 3) Per cent change against previous month.

To test their scheme, M/W classified periods which had not been used for the estimation of their functions, a test that ranks high in discriminant analysis. In the present case its power is very much limited: for technical reasons, since the number of observations/cases is comparatively small, and for material reasons, because over a period of 50 years economic relationship it can hardly be expected to be stable, as will be shown later.

Results for both “back-casting” – after some modifications of the classifying variables and their periodicity – for the period 1920 to 1951 and for forecasting with the original variable set (1973-10 to 1974-9) were seen by M/W as confirmations of their scheme (M/W 1975a, pp. 184ff.).

Before extending the M/W scheme to 1997, as is done in the next section, we tried to reproduce their results. Because of revisions, redefinitions etc. of the data, this is a notoriously burdensome and indecisive exercise. Most of the M/W variables were seasonally adjusted and de-trended by transforming them to annual percentage rate changes. Because some variables were not available for us in seasonally adjusted form, we decided to de-trend by using change rates against the previous year: a simple, usually effective method of seasonal adjustment. One important consequence of this was – besides only a small number of missing variables – that the start of our analysis was shifted forward by fifteen months. A further difference to M/W is that interest rate changes were calculated as percentage changes per month. The variables used and their average values are listed in Table 2 (line a).

Also different from M/W, we opted for the use of three discriminant functions, but this had no consequences for the parameters of the first two functions. Finally, in all analyses, Money GNP was excluded from the set of classifying variables, because it failed tolerance tests, especially in short sample periods. Results with considerably smaller sets of variables were to a large extent similar to those derived with the 19 variables, but for comparison with M/W we present results with the larger set. All in all, the reproduction appears rather convincing for both the discriminant functions (Table 3, line a) and the quality of explanation (Cumulative percent explanation). With the F-values to enter, the new results differ most of all with respect to Government Surplus, GNP deflator and Prime rate, which sink from ranks 4, 5 and 6 to ranks 19, 11 and 15 respectively. Correspondingly, the Consumer price index (excluding food) went up to rank 5. The classification results with the newly estimated three discriminant functions improved slightly and the total error rate fell from 10 percent (31 cases) to 9 percent (27 cases), mainly because the explanation of Demand-Pull stages has been improved. However, it should be remembered, that Stagflation, like in M/W's final classification, is identified only in 4, and Demand-Pull only in 5 of the first 6 post-WWII cycles. Table 1* in the appendix presents the misclassified periods of M/W's analysis and our re-estimation.

II. Stability of Meyer/Weinberg's scheme

These results are not all too astonishing, but they still give confidence to extend the analysis forward to 1997. Although, since the 1970s and its high inflation rates, the U.S. cycle has changed (again) (Gordon (ed.) 1989), the new sample period should help to identify dates and phenomena (variables) of such changes. The long time span that had elapsed since M/W developed the scheme, offers a number of ways to do this. They range from re-formulation of the classification scheme in general to a re-specification of the discriminant functions and to the selection of a shorter, thus less general, sample period. We concentrate on only two, but principally different, ways. First, we examine the classification power of discriminant functions estimated over the period 1948/73 to classify the 1974/97 period. Second, starting with the M/W sample period we re-estimate the functions by successively including later cycles. However, to check the classification power, we first had to establish the *a priori* classification of the new part of the sample period. This was done – similar to M/W -, with the help of the discriminant functions to be tested, which, of course, weakens (again) the power of classification tests.

1. Establishing the 4-phase classification for 1973 to 1997

The classification procedure follows the route taken by M/W (1975a) and was, again, an iterative procedure. It started with the two-phase classification of 1973/97 by the NBER, split into Recovery/Demand-Pull and Stagflation/Recession. This *a priori* classification of the new sample period was modified according to the classification results of discriminant functions, estimated over various sample periods. The classification of the resulting five new cycles from 1973 to 1997 is displayed in Table 1. As could be guessed from the previous results and from history since 1973, Stagflation is identified only in *one* of the five new cycles.

To get an impression of the economic content of this classification, Table 2 (line b) presents average values for the classifying variables. The results are mostly in line with the prevailing knowledge of the stylised facts of the U.S. cycle. When compared with averages of the M/W-sample (1948-5 to 1973-9), the levels of some variables (rates of change) are different, but the structure of the four phases is still much the same as that of M/W.

2. Outside sample performance of the original Meyer/Weinberg scheme

A further hint of the appropriateness and hence the stability of the newly estimated M/W scheme is its classification performance for the complete sample period (1948 to 1997). Technically, this is a *within-/outside*-sample period test by a mixture of classifications. The overall error rate (not shown here) increases from 9 percent to more than 60 percent, which signals a stability problem of the scheme over the whole sample period. The deterioration is not continuous; particularly bad results are experienced for the two inflation periods. But ex-post forecasts outside the sample period, over a period twice as long as the sample period, would expose severe stability problems in any case, even for the permanent income hypothesis. The shift in succession of the phases presented in Figure 1, however, can be traced to the late 1960s.

Table 4

Classification results for different samples

1948-5 to 1997-12

	No. of cases	Recovery	Demand-Pull	Stagflation	Recession
			1948-5 to 1973-9		
Recovery	116	103	5	0	8
		88.8%	4.3%	0.0%	6.9%
Demand-Pull	76	1	74	0	1
		1.3%	97.4%	0.0%	1.3%
Stagflation	66	0	2	63	1
		0.0%	3.0%	95.5%	1.5%
Recession	47	4	3	2	38
		8.5%	6.4%	4.3%	80.9%
Total error rate 8.9 %					
			1948-5 to 1997-12		
Recovery	249	201	27	1	20
		80.7%	10.8%	0.4%	8.0%
Demand-Pull	149	35	93	18	3
		23.5%	62.4%	12.1%	2.0%
Stagflation	102	7	20	73	2
		6.9%	19.6%	71.6%	2.0%
Recession	96	1	1	9	85
		1.0%	1.0%	9.4%	88.5%
Total error rate 24.2 %					
			1961-2 to 1997-12		
Recovery	209	171	17	7	14
		81.8%	8.1%	3.3%	6.7%
Demand-Pull	113	9	97	6	1
		8.0%	85.8%	5.3%	0.9%
Stagflation	61	0	0	61	0
		0.0%	0.0%	100.0%	0.0%
Recession	60	1	0	8	51
		1.7%	0.0%	13.3%	85.0%
Total error rate 14.2 %					
			1970-12 to 1997-12		
Recovery	158	131	8	11	8
		82.9%	5.1%	7.0%	5.1%
Demand-Pull	82	4	77	1	0
		4.9%	93.9%	1.2%	0.0%
Stagflation	36	0	0	36	0
		0.0%	0.0%	100.0%	0.0%
Recession	49	2	0	0	47
		4.1%	0.0%	0.0%	95.9%
Total error rate 10.5 %					
			1975-4 to 1997-12		
Recovery	133	119	5	5	4
		89.5%	3.8%	3.8%	3.0%
Demand-Pull	61	0	59	1	1
		0.0%	96.7%	1.6%	1.6%
Stagflation	36	1	0	35	0
		2.8%	0.0%	97.2%	0.0%
Recession	43	0	0	0	43
		0.0%	0.0%	0.0%	100.0%
Total error rate 6.2 %					
Recovery	94	90	0	3	1
		95.7%	0.0%	3.2%	1.1%
			1980-12 to 1997-12		
Demand-Pull	49	0	49	0	0
		0.0%	100.0%	0.0%	0.0%
Stagflation	36	0	0	36	0
		0.0%	0.0%	100.0%	0.0%
Recession	28	0	0	1	27
		0.0%	0.0%	3.6%	96.4%
Total error rate 2.4 %					

Authors' computations.

3. Estimation and classification results of the Meyer/Weinberg scheme with the new sample

The estimation results over the new sample (1975-4 to 1997-12) show a new ranking of the F-values to enter (Table 3, line b), in particular Unemployment and Real GNP, which could perhaps already be expected from the average values. Only four of the 19 variables corroborate previous results: Gross government expenditure, M1, Compensation per man-hour, and Output per man-hour. Most of them are of minor importance in the functions.

The weight, as indicated by the F-value to enter, for most variables has been reduced, in particular that of indicators of inflation. Only the importance of Real GNP and Net exports as a percentage of GNP – indicators of economic activity – have strengthened. Hence, economic interpretation of these results must be made cautiously – the results seem to underline that, with the exception of Unemployment rate, inflation-related variables lost discriminating power.

The “explained variance” (Table 3) for the first discriminant function – assumed to discriminate between Recovery and Demand-Pull is reduced from nearly 70 percent to 50 percent, corresponding with a doubling of this ratio in the second function from 20 percent to 40 percent. This also confirms the picture emerging from the F-values.

The total error rate of classification declines over the new sample period to nearly six percent – somewhat better than what has been recorded here for the old M/W-sample (Table 4). Improvements concentrate on Recession periods.

4. Stability of the newly estimated Meyer/Weinberg scheme

Looking at the picture of U.S. cycles as chronicled in Table 1, Stagflation, together with Demand-Pull, one of the major features of M/W’s “modern business cycle”, now completely lose significance. While only three Stagflations were identified in the six

Table 5

Error rates
of leave-one-cycle-out classifications[1]
1948-5 to 1997-12

	Cycle	Recovery	Demand-Pull	Stagflation	Recession	All
1	1948-5 to 1949-10	…	…	57	0	22
2	1949-11 to 1954-7	25	33	65	0	46
3	1954-8 to 1958-4	57	100	-	0	75
4	1958-5 to 1961-1	16	-	0	12	15
5	1961-2 to 1970-11	18	77	44	91	46
6	1970-12 to 1975-3	100	19	-	0	56
7	1975-4 to 1980-9	79	67	-	60	73
8	1980-10 to 1982-12	100	100	-	33	63
9	1983-1 to 1991-12	0	100	100	61	81
10	1992-1 to ...1997-12	100	-	…	…	…
	Total sample period 1948-5 to 1997-12	19	38	28	12	24

Authors'computations – 1) Summary of Table 2*, appendix.

cycles classified by M/W, the following four cycles experience only one. Although M/W and others, e.g. *Eckstein/Sinai* (1986), had not presumed that cycles must always comprise all phases, the disappearance of this stage is a serious challenge for the M/W scheme. A consequence of the missing stage may be seen in the sequence of all phases as given by the first two discriminant functions (see Figure 1). While for the M/W and the complete sample period, the succession of phases is "natural" (recession → recovery → demand pull → stagflation → recession → …), the 1974/1997 period attracts attention by exchanging the two inflation periods.

Compared to the old sample, lengths of cycles and phases have been rather stable. Restricted to full cycles, the average duration is still 62 months (NBER: 63). Recoveries now last 22 months (M/W: 23), Demand-Pull 21 months (22), Stagflations 32 months (30) and Recessions 9 months (11 months).

A similar picture emerges from more explicit stability tests. While the classification results for various post 1973 samples continuously improve, as signalled by total error rates (in Table 4 shown only for 1980/1997), the stability, as indicated by the "leave on cycle out" results outside the sample period, is continuously worsening (see Table 5 and in detail Table 2*, appendix). The verdict is moderated when considered that for the M/W-sample this test produces error rates of more than 40 percent for cycles 2, 3, 5 and 6. Again, given the long time span, to expect a stable explanation "outside the sample period" is not very realistic. Leave-one-out tests may be an adequate test in biology or geology and a number of other natural science branches, but hardly in economics, where non-stationary and change are characteristics of the subject. Here, forward and backward recursive estimations appear to be more realistic and promising tests.

Looking for "causes" of this deterioration, a first explanation is found in the unfolding of co-factors, i.e. the average values.[7] The changed levels of most price variables (e.g. GNP price deflator) and of some indicators of economic activity make it clear that M/W's new cyclical experience was of episodic nature only.

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7 In econometrics, this problem can be solved or at least mitigated by analysing elasticities, but this is not possible here.

III. Summary and conclusion

The re-estimation of M/W's classification over the old sample period and its extension forward to 1997 showed a remarkable stability of the 4-phase scheme itself and of its constituting variables. Surprisingly, the classificationary performance over the post 1973 period proved much better than that for the pre 1973 period and for the complete sample period. This points towards shifts in the cyclical picture and towards changing importance of the classifying variables within the four stages. While the roles of the most important variables such as real GNP, Unemployment rate, Consumer price index, and Money supply seem to have been rather stable, at least temporarily, that of Net exports and Consumer prices increased and improved the explanation of the "two inflation phases". The findings suggest that M/W's scheme was only of temporary relevance. Whether it can be integrated in a more comprehensive system remains to be shown. While length and intensity of U.S. cycles show a remarkable stability over the post WWII period, present results and previous findings (e.g., Eckstein/Sinai 1986) raise doubts that the same variables had the same, unchanged influence. Nevertheless, the M/W scheme offers some promising perspectives. Leaving open future uses of the scheme, the base of classifiers for further examinations of the U.S. cycle should be broadened in mainly two directions.[8] First, variables not used in the discriminant functions should be classified and their cyclical behaviour should be examined. The more than 30 variables classified by *Mitchell* (1951, pp. 256ff.), including also "modern" indicators such as net government activities or government deficit/GDP ratios, net export/GDP ratios, or additional indicators of monetary policy, appear to be a promising start. Of course, the list should also include data on orders, order logs or subjective data (indices of consumer sentiment, purchasing managers index, etc.). Discriminant analysis is open to variable selection, although the results may be more convincing, the better the theoretical foundation of their use. But the outcomes of discriminant analysis should not be the only or the last word on cyclical relevance. A

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8 The test of additional classification methods appears to have lower priority. Robustness and clarity of linear discriminant analysis make it, in the present context, first choice (Heilemann, Münch 1996).

second, more elementary avenue could be the re-specification of the discriminant functions. Here too, present findings deliver promising candidates. There is no doubt that the rather limited number of spheres included in M/W's set of variables should include more demand aggregates such as investment, consumption, stocks etc. Certainly the high multicollinearity of many of these variables and the low number of observations and cycles/stages limit the set of variables to be identified. Nevertheless, examinations of the M/W-scheme for Germany, modified along the lines suggested above, provided surprisingly good and stable results.

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Appendix

Linear discriminant analysis

Modern classification analysis comprises a multitude of procedures for separation of groups and objects. Besides the oldest and most simple technique of linear discriminant analysis (LDA, see Heilemann, Weihs 2000), a number of modern procedures such as neural networks (NN, see Ripley 1994) and classification trees (TREE, see Breiman et al. 1984) have been developed. Their main innovation is the way in which they separate the groups (here: phases of the business cycle) in the multidimensional space. The reasons for applying LDA here are, as in most other studies, its robustness, its particularly large analytical possibilities and its clarity due to the linear character of the discriminant functions (see Erb 1990, p. 5). Given the limited space of this paper, it reports only on LDA results.

The main objective of LDA (and, of course, any other classification method) is to classify objects by a set of independent variables $x_1, ..., x_m$ into g given groups,

$$y_i = c_1 x_1 + ... + c_m x_m \tag{1}$$

where

y_i: dependent (grouping) variable, with i = 1, ..., g (number of groups with $g \geq 2$);

x_j: independent variables, j = 1, ..., m;

c_j: coefficients.

For n cases, the observations $x_1,...,x_m$ of the m-dimensional criterion are given. The observations of the (n,m)-matrix

$$\mathbf{x} = \begin{bmatrix} x_1' \\ \cdot \\ \cdot \\ \cdot \\ x_n' \end{bmatrix} = \begin{bmatrix} x_{11} & \cdot & \cdot & \cdot & x_{1m} \\ \cdot & & & & \\ \cdot & & & & \\ \cdot & & & & \\ x_{n1} & \cdot & \cdot & \cdot & x_{nm} \end{bmatrix} \tag{2}$$

arise from g different groups or classes, and so **x** can be partitioned into g (n_k,m)-submatrices (with $n = n_1 + ... + n_g$):

$$\mathbf{x} = \begin{bmatrix} \mathbf{x}_1 \\ \cdot \\ \mathbf{x}_k \\ \cdot \\ \mathbf{x}_g \end{bmatrix} \tag{3}$$

with $\mathbf{x}_k = \left(x_{k1},...,x_{ki},...,x_{kn_k}\right)'$ containing the observations from group G_k $(k = 1, ..., g)$

In the simple case of two groups, (3) reduces to

$$x_1' = \left(x_{11},...,x_{1n_1}\right) \text{ and } x_2' = \left(x_{21},...,x_{2n_2}\right). \tag{4}$$

By a linear transformation of the m-dimensional vector of observations x to a scalar, the m-dimensional problem becomes a 1-dimensional one:

$$y_i = c_1\ x_1 + c_2\ x_2. \tag{5}$$

In LDA, the coefficients (c_j) are estimated in such a way that the values of the discriminant function (5) differ as much as possible *between* the groups, or so that for the discriminant scores the ratio

$$\frac{\text{between} - \text{groups sum of squares}}{\text{within} - \text{groups sum of squares}} \tag{6}$$

is maximized.

In the general case of $g \geq 2$ groups, a maximum number of min(m,g-1) discriminant functions can be derived. The first function has the largest ratio of between-groups to within-groups sums of squares. The second function is orthogonal to the first and has the next largest ratio, and so on. Because the coefficients of the different discriminant functions are derived from a classic intrinsic value problem (Erb 1990, p. 36), special norming conditions have to be set up to achieve unique solutions.

The main questions about classification scheme being asked and answered by LDA are:

- How well do the variables discriminate between given groups?
- Which variables are good discriminators?
- What decision rule should be used for classifying (new) objects?

Table 1*

Misclassifications 1948-5 to 1973-9

Year	Month	Phase	M/W results	Authors' re-estimation
1948	May	stagflation	dem. pull	
	June	stagflation	dem. pull	
	Nov.	stagflation	dem. Pull	recession
1949	Oct.	recession		recovery
	Nov.	recovery		recession
	Dec.	recovery		recession
1950	April	recovery		dem. pull
	May	recovery		dem. pull
	June	recovery		dem. pull
1951	March	stagflation		dem. pull
1953	Nov.	recession	stagflation	stagflation
1954	August	recovery		recession
1955	Jan.	recovery		dem. pull
	Febr.	recovery		dem. pull
	April	dem. pull		recovery
1956	Febr.	dem. pull	stagflation	
	June	dem. pull		recession
	Oct.	dem. pull	stagflation	
1957	Sept.	recession		dem. pull
	Oct.	recession		dem. pull
	Nov.	recession		dem. pull
1958	May	recovery	recession	recession
	June	recovery		recession
1959	July	recovery	recession	
	August	recovery	recession	
1960	March	recovery	recession	
	April	recovery		recession
	May	recovery	recession	recession
	August	recession	recovery	
	Oct.	recession		recovery
	Nov.	recession		recovery

Table 1*, continued

Year	Month	Phase	M/W results	Authors' re-estimation
1961	Jan.	recession		recovery
1962	July	recovery	recession	
	Oct.	recovery	recession	
1964	July	recovery	dem. pull	
1965	Dec.	dem. pull	stagflation	
1966	Febr.	dem. pull	stagflation	
	Sept.	dem.pull	stagflation	
	Oct.	dem. pull	stagflation	
	Nov.	dem. pull	stagflation	
1967	Febr.	dem. pull	stagflation	
	March	dem. pull	stagflation	
	May	dem. pull	stagflation	
	July	dem. pull	stagflation	
1968	March	stagflation		dem. pull
	Dec.	stagflation	dem. pull	
1969	Dec.	stagflation	dem. pull	
1970	Jan.	recession	dem. pull	stagflation
	April	recession	dem. pull	
	May	recession	dem. pull	
	July	recession	recovery	
	Dec.	recovery		recession
1973	May	dem. pull	recovery	

Source: Meyer/Weinberg and authors' computations.

Table 2*

"Leave-one out" classifications[1]
1948-5 to 1997-12

Actual group	No. of cases	Predicted group membership: Recovery	Demand-Pull	Stagflation	Recession
		All			
Recovery	249	201	27	1	20
		80.7%	10.8%	.4%	8.0%
Demand-Pull	149	35	93	18	3
		23.5%	62.4%	12.1%	2.0%
Stagflation	102	7	20	73	2
		6.9%	19.6%	71.6%	2.0%
Recession	98	1	1	9	85
		1.0%	1.0%	9.4%	88.5%
Total error rate: 24.2%					
		"Leave one out"[1]			
Recovery	249	190	35	1	23
		76.3%	14.1%	.4%	9.2%
Demand-Pull	149	39	88	18	4
		26.2%	59.1%	12.1%	2.7%
Stagflation	102	7	22	70	3
		6.9%	21.6%	68.6%	2.9%
Recession	98	1	1	10	84
		1.0%	1.0%	10.4%	87.5%
Total error rate: 27.2%					
		Without cycle 1 (1948-5 to 1949-10)[2]			
Recovery	0	0	0	0	0
		.0%	.0%	.0%	.0%
Demand-Pull	0	0	0	0	0
		.0%	.0%	.0%	.0%
Stagflation	7	0	0	3	4
		.0%	.0%	42.9%	57.1%
Recession	11	0	0	0	11
		.0%	.0%	.0%	100.0%
Total error rate: 22.2%					

Table 2*, continued

Actual group	No. of cases	Predicted group membership: Recovery	Demand-Pull	Stagflation	Recession
		Without cycle 2 (1949-11 to 1954-7)[2]			
Recovery	8	6 75.0%	0 .0%	0 .0%	2 25.0%
Demand-Pull	6	2 33.3%	4 66.7%	0 .0%	0 .0%
Stagflation	34	0 .0%	22 64.7%	12 35.3%	0 .0%
Recession	9	0 .0%	0 .0%	0 .0%	9 100.0%
Total error rate: 45.6%					
		Without cycle 3 (1954-8 to 1958-4)[2]			
Recovery	7	3 42.9%	0 .0%	0 .0%	4 57.1%
Demand-Pull	30	11 36.7%	0 .0%	8 26.7%	11 36.7%
Stagflation	0	0 .0%	0 .0%	0 .0%	0 .0%
Recession	8	0 .0%	0 .0%	0 .0%	8 100.0%
Total error rate: 75.6%					
		Without cycle 4 (1958-5 to 1961-1)[2]			
Recovery	25	21 84.0%	0 .0%	0 .0%	4 16.0%
Demand-Pull	0	0 .0%	0 .0%	0 .0%	0 .0%
Stagflation	0	0 .0%	0 .0%	2 100.0%	0 .0%
Recession	8	1 12.5%	0 .0%	0 .0%	7 87.5%
Total error rate: 15.2%					

Table 2*, continued

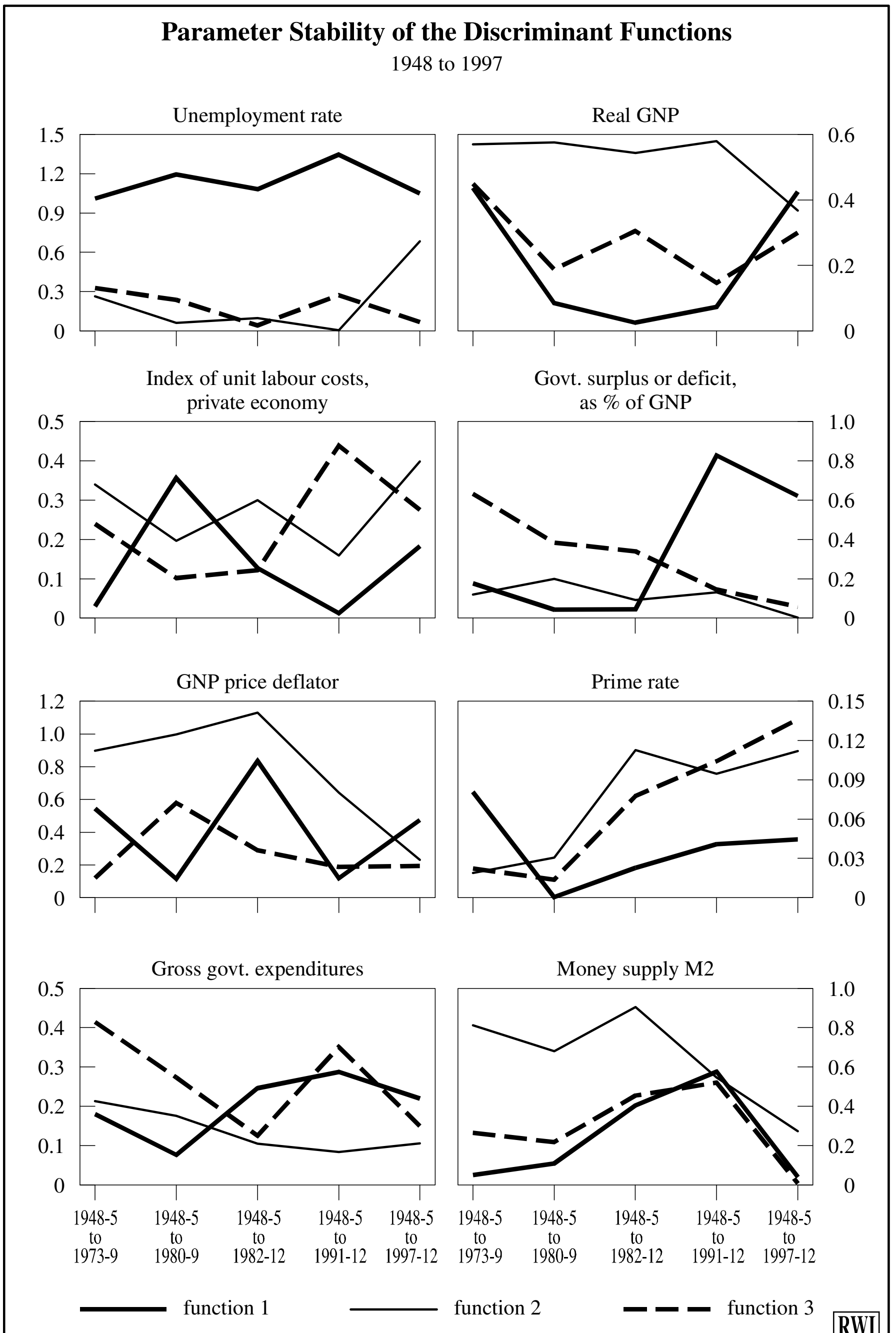
Actual group	No. of cases	Predicted group membership: Recovery	Demand-Pull	Stagflation	Recession
		Without cycle 5 (1961-2 to 1970-11)[2]			
Recovery	51	42 82.4%	8 15.7%	0 .0%	1 2.0%
Demand-Pull	31	2 6.5%	7 22.6%	22 71.0%	0 .0%
Stagflation	25	0 .0%	11 44.0%	14 56.0%	0 .0%
Recession	11	0 .0%	1 9.1%	9 81.8%	1 9.1%
Total error rate: 45.8 %					
		Without cycle 6 (1970-12 to 1975-3)[2]			
Recovery	25	0 .0%	24 96.0%	0 .0%	1 4.0%
Demand-Pull	21	0 .0%	17 81.0%	0 .0%	4 19.0%
Stagflation	0	0 .0%	0 .0%	0 .0%	0 .0%
Recession	6	0 .0%	0 .0%	0 .0%	6 100.0%
Total error rate: 55.8 %					
		Without cycle 7 (1975-4 to 1980-9)[2]			
Recovery	39	8 20.5%	24 61.5%	0 .0%	7 17.9%
Demand-Pull	12	0 .0%	4 33.3%	8 66.7%	0 .0%
Stagflation	0	0 .0%	0 .0%	0 .0%	0 .0%
Recession	15	0 .0%	0 .0%	9 60.0%	6 40.0%
Total error rate: 72.7 %					

Table 2*, continued

Actual group	No. of cases	Predicted group membership: Recovery	Demand-Pull	Stagflation	Recession
		Without cycle 8 (1980-10 to 1982-12)[2]			
Recovery	6	0 .0%	0 .0%	0 .0%	6 100.0%
Demand-Pull	6	3 50.0%	0 .0%	0 .0%	3 50.0%
Stagflation	0	0 .0%	0 .0%	0 .0%	0 .0%
Recession	15	5 33.3%	0 .0%	0 .0%	10 66.7%
Total error rate: 63.0 %					
		Without cycle 9 (1983-1 to 1991-12)[2]			
Recovery	16	16 100.0%	0 .0%	0 .0%	0 .0%
Demand-Pull	43	43 100.0%	0 .0%	0 .0%	0 .0%
Stagflation	36	36 100.0%	0 .0%	0 .0%	0 .0%
Recession	13	8 61.5%	0 .0%	0 .0%	5 38.5%
Total error rate: 80.6 %					
		Without incomplete cycle 10 (1992-1 to …(1997-12))[2]			
Recovery	72	0 .0%	31 43.1%	41 56.9%	0 .0%
Total error rate: 100.0 %					

Authors' computations. – 1)Successive elimination of one month from the sample period. – 2)Sample period without corresponding cycle.

Figure 1*



Authors' computations.

Figure 1*, continued

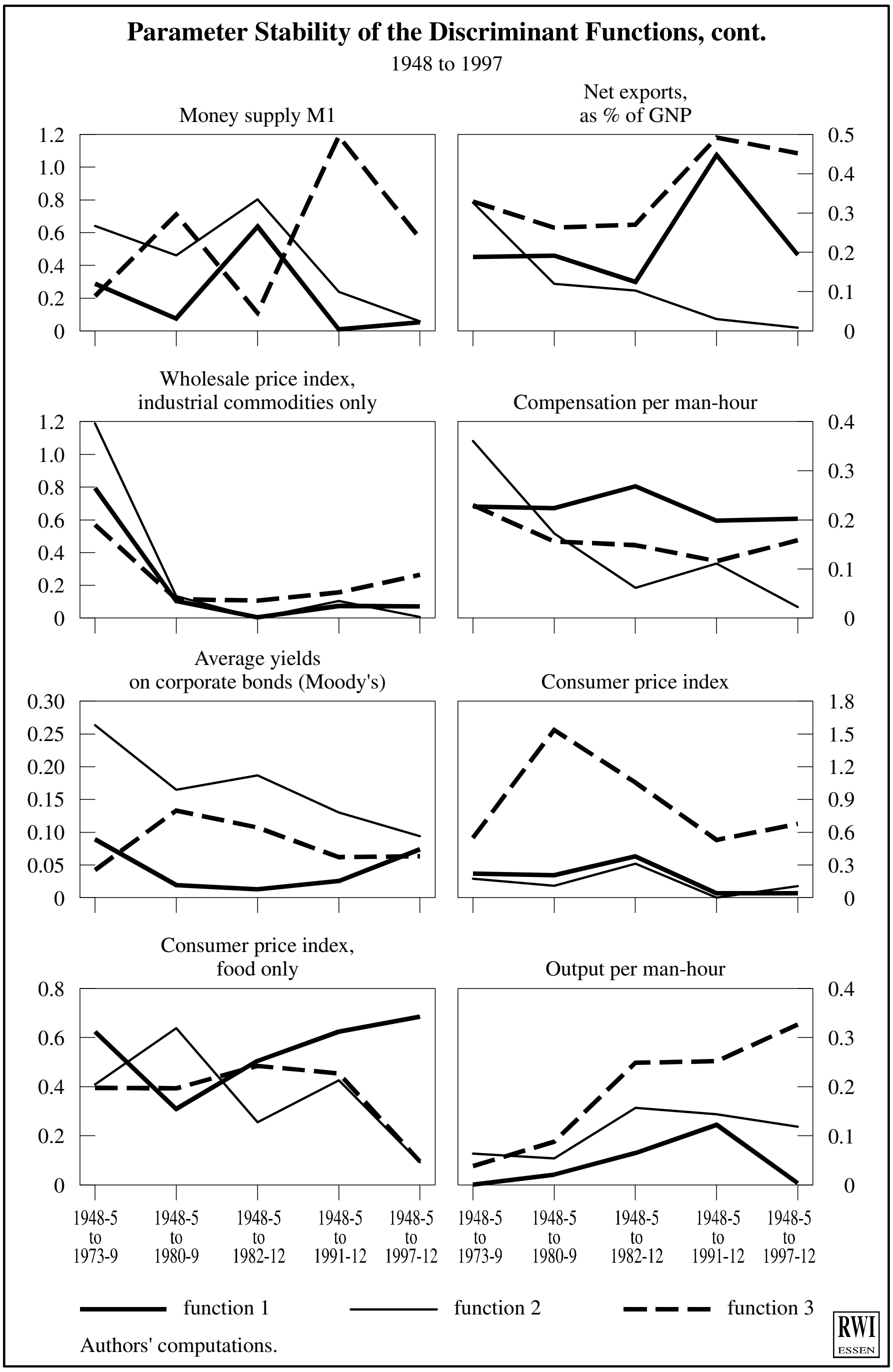
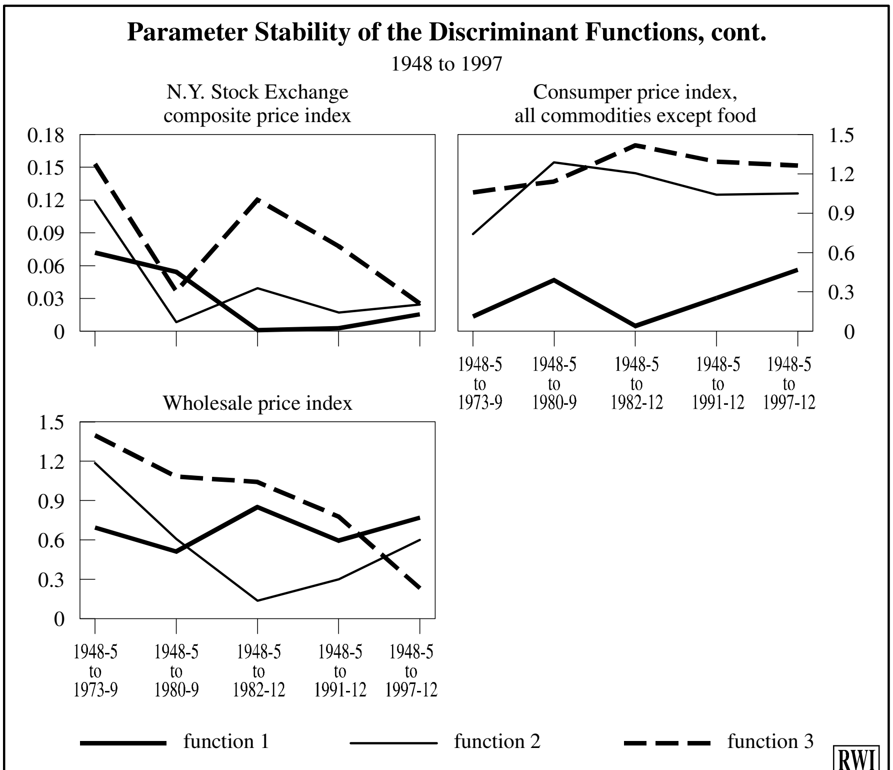


Figure 1*, continued



Authors' computations.