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An Econometric Analysis of Detecting Structural Changes in the Seven Major Exchange Rates with MAIC Method : January, 1974 through September, 1986

Hiroya Akiba*
and
Tomoki Waragai**

Abstract

This paper tries to identify the particular point of time when the foreign exchange market undergoes a significant structural change which could be a possible reason why most existing models of exchange rate determination fail to explain exchange rate movemets and forecast for out-of -sample periods. The technique developed by the writers is a new application of MAIC, bringing it one more step further. It is also superior to traditional methods because of its arbitrary-free characteristic of detecting structural changes. Seven major currencies vis-a-vis the U. S. dollar are examined for the recent floating period.

* Department of Economics, Niigata University, Niigata, Japan

** Universitat Bonn, Bonn, West Germany and Waseda University, Tokyo, Japan

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I. Introduction

The primary purpose of this paper is to show that the poor performance of the out-of-sample forecast by structural models of the exchange rate determination is a possible consequence of structural changes at some point of time in the foreign exchange market, and the structural models have not considered such changes adequately.[1] Taking qualitatively heterogeneous data as homogeneous and estimating structural models, whether they are time-series or regression models, would result in a fall in the reliability of models as Backus (1984) concluded. Here, we are interested in ascertaining the particular point of time when structural changes occurred in the foreign exchange market as the first step to constructing a better model to explain the movements of the foreign exchange rates. Since there are several novelties in our analysis, they should be explained briefly.

First of all, we employ the time-series model, in particular an autoregressive (AR) model, that is normally used for predictions in economics, in order to identify structural changes. It is natural to first focus on the movement of data itself in examining the qualitative characteristics. The AR model has another desirable feature in that it is free from the problem of arbitrariness arising from the choice of explanatory variables in any regression models to test structural changes.[2], [3]

Secondly, the MAIC(minimization of the AIC, Akaike's Information Criterion) method is employed to identify structural changes, as well as to select the order of the AR model. Since the MAIC method implies minimization of the Kullback-Leibler information measure, it can serve as a powerful alternative to the test of hypothesis

1. Thus, our analysis does not concern itself with estimation or insample fit, but is closer in spirit to Gregory and McCurdy (1984), and Messe and Rogoff (1983a, 1983b).
2. As Meese and Rogoff (1983a, 1983b) indicate, a univariate time series or a vector time series model has some predictive power. Furthermore, such time series models have another desirable character in that they do not depend on any particular economic theory. Since regression models are in general based on and are supposed to test some economic hypothesis, it is hoped that these two models, i.e., time series models and regression models, serve as a complement to each other.
3. There are other time series models that could be alternatives to an AR model : An ARMA model with a moving average process, or an ARIMA model in which the time trend can be handled. We took up an AR model because, (1) much more data are needed for ARMA or ARIMA models, and (2) interpretation is easier for an AR model. It should be emphasized that "structural changes" include also changes in trend factor. For the procedure of eliminating a trend factor from each divided subprocess, see section II (footnote 8).

method which has inherently an arbitrariness in determination of the significance levels.[4] Here, however, we apply the MAIC method one more step further to the analysis of structural change. Our method is an alternative and is superior in identifying structural changes to the traditional methods, such as the Chow test, etc. These depend on some arbitrariness in selecting the significance levels.

In our analysis, monthly observations from January 1974 through September 1986 (153 samples), for the exchange rates of the pound sterling, Deutsche mark, Canadian dollar, Swiss franc, French franc, Dutch guilder, and Japanese yen, vis-à-vis the US dollar are used. It is shown statistically that the foreign exchange markets underwent structural changes. The most significant structural change occurred in (1) Sept.-Oct., 1985 for the Deutsche mark, the Dutch guilder, the pound sterling and the Japanese yen, (2) Dec., 1980-Jan., 1981 for the French franc, (3) Dec.,1975-Jan.,1976 for the Canadian dollar, and (4) Dec.,1974-Jan.,1975 for the Swiss franc. However, for the Canadian dollar, many such changes could be identified, supporting Backus' conclusion that all regression models are false unless such structural changes are taken into consideration. Our finding would suggest that, if we were to construct regression models to forecast the future exchange rates, careful treatment of regressing time period and deliberate selection of explanatory variables are needed in order to take such structural changes into consideration.

The organization of the paper is as follows : In section II, the formulation of our experiment is outlined in some detail. Section III is devoted to presenting our calculation results and to identifying the point of time when each exchange rate underwent structural changes. Section IV briefly discusses the robustness of our results by comparing them with those of a traditional statistical test of structural change. In section V we briefly discuss each point of time of structural change by going into the historical data of each exchange rate. The final section summarizes our analytical method and conclusions.

II. Formulation of Experiment

In this section the technique we employ in this paper is explained in some detail.[5]

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4. The MAIC method has been employed in econometric works to select the order of AR models. Here, we also apply the MAIC method to select the order of AR model in order to avoid an arbitrariness.

5. The basic idea was developed in Waragai (1986).

The method is called the MAIC(minimization of the AIC, Akaike's Information Criterion) which can be used to detect the particular point of time when a structural change occurred.

Suppose there is a set of random data $\{x(t)\}$ of the random variable X(t), which is a time history of the exchange rate of each currency vis-à-vis the U.S. dollar.[6] In order to eliminate time trend components from the data, it is simply assumed that $\{x(t)\}$ have a trend factor $\mu(t)=\alpha+\beta t$. Parameters α and β are estimated by the least squares method :

$$\min \sum \{x(t)-\mu(t)\}^2 \tag{1}$$

Next, let us define z(t) as

$$z(t)=x(t)-\hat{\mu}(t) \tag{2}$$

where $\hat{\mu}(t)=\hat{\alpha}+\hat{\beta}t$ ($\hat{\alpha}$ and $\hat{\beta}$ are the least square estimators). It is assumed that the random process $\{z(t)\}$ could be generated from an autoregressive (AR) model :

$$z(t)=\sum_{i=1}^{p} a_i z(t-i)+u(t) \tag{3}$$

where p is the order of the AR model, a_i the coefficients, and u(t) white noise, N $(0, \sigma^2)$. Both the Yule-Walker equation and the AIC are utilized for estimation of a_i and determination of the order p. For this end the AIC is employed and is given by the follwing equation without common term :

$$AIC=N\log\hat{\sigma}^2+2p \tag{4}$$

$$\text{where } \hat{\sigma}^2=-\sum_{k=0}^{p} \hat{a}_k \hat{r}_{k-j} \qquad a_0=-1 \tag{5}$$

$$\hat{r}_j=\sum_{k=1}^{p} \hat{a}_k \hat{r}_{k-j} \qquad j=1,\cdots, p \tag{6}$$

$$\hat{r}_k=\sum_{i=1}^{N-k} Z(i)Z(i+k)/N \tag{7}$$

6. The sample exchange rates are explained in the next section. For randomness of exchange rates, see, e. g., Mussa (1979).

The model given by minimizing AIC can be considered the AR model best fitted to the data $\{z(t)\}$.

The method employed up to here is the identification procedure of the stationary random process. If we are to detect structural changes utilizing the AR model, it is necessary to fit an AR model in non-stationary situations. To detect a non-stationarity Ozaki and Tong (1975) employed the AIC method. In the rest of this section we outline (hinted by Ozaki and Tong's work) how to apply the AIC method to detect a structural change in $\{z(t)\}$.[7]

A random process with a structural change can be considered non-stationary for the whole process, i.e., before and after the structural change. However, each process of before and after the structural change may be considered a stationary process. Figure 1 illustrates our application of the AIC method for detection of a structural change.

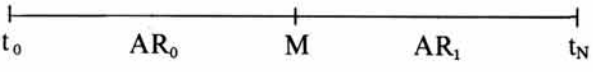

Figure 1

If an AR process is divided into two subprocesses at time M, let the AR_0 model with the order p_0 and AIC_0 be best fitted to the data before time M,[8] and the AR_1 model with the order p_1 and AIC_1 best fitted to those after M. Then, the AIC_M throughout the process is defined as $AIC_M = AIC_0 + AIC_1$. Since the AIC is an information measure that indicates the poorness of fit, it is the time M* defined by

$$AIC_{M^*} = \min AIC_M$$

that can be considered to divide the whole process best into two subprocesses.[9] In

7. The term "structural" change should be interpreted as having purely statistical meaning, although the statistical meaning would include economic meanings.
8. It should be pointed out that the procedure of equations (1) and (2) for eliminating a trend factor is applied to each divided subprocess of $\{x(t)\}$ for (t_0, M) and for (M, t_N). This means that changes in the trend factor are taken into consideration before and after M.
9. Here it is assumed that there exists only one breakpoint in a whole process. It is no wonder that one should ask (1) whether a structural change has occurred at all, and (2) whether two or more changes have occurred. The first question is resolved by comparing the AIC_M with the AIC_A (for all data assuming no stuctural change), as we did in footnote 24, and by invoking an empirical criterion that the difference between AR(A) and AR(M) is

other words it would be possible to consider that a structural change occurred at the time M* .[10]

Ⅲ. Computation Results of AIC [11]

The data are monthly observations (the end of month) of the foreign exchange rates for seven major currencies vis-à-vis the U.S. dollar.[12] The sample period covers the recent floating period since early 1973, but for our calculation of the time period M*, January 1974 was selected as the starting period because it ensures stability of the estimators.[13]

In order to avoid any arbitrariness and to increase the accuracy as much as possible, we set the follwing criteria: (1) For every currency the data were divided by every six months in principle. (2) We also divided the data on the occasion when the exchange rates of European currencies were realigned and when structural changes were suspected

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significant if $|AIC_A - AIC_M|$ is greater than 1 or 2 (the second remark of Sakamoto, et al. (1983), chapter 4, section 4.6, p. 63.) The second question is also resolved by utilizing this second remark: If there is (are) other point(s) M*, such that $|AIC_{M*} - AIC_{M*}| <$ (or 2) (which means that the difference is not significant, i.e., the process could be divided into at least three subprocesses), more than two breakpoints are suspected and the whole process is divided into several subprocesses. Then, on can apply the MAIC method and calculate the AIC to identify the true M* for each subprocess. Here, applying this method to the calculated AIC in Tables 1−7, it is Judged and assumed that there is one breakpoint for each exchange rate. For more detail, see, e.g., Waragai (1987). Because the application methed in this paper was devised in order to indentify a turning point within a process, the second question should be further examined form statistcal and economic viewpoints.

10. According to Dr. W.S. Chow, it may be possible to summarize roughly that the application by Ozaki and Tong (1975) is colser to the t-test in spirit, while our new application to the F-test.

11. The actual value of AIC were calculated by, instead of equation (4), $AIC = N\log\hat{\sigma}^2 + 2(p+2)$ (see Ozaki and Tong (1975). If, because of eliminatin the time trend from z(t) (see equation (2)), an increase in parameters is also taken into consideration, the last term of equation (4) should be 2(p+4). However, such modification will only make AIC greater by either 2 or 4, and will not alter the final conclusion.

12. All data are from the International Monetary Fund-International Financial Statistics, various issues.

13. September, 1986 was selected as the end point because of the data availability at the time of estimation.

from data observation.

The computation results are summarized in Tables 1 through 7. [14] From the purely statistical point of view, i.e., according to the MAIC method, it is apparent that the following conclusions are derived from the tables.[15]

(A) The United Kingdom–Table 1 and Figure 2

The exchange rate of the pound sterling underwent the most significant structural change in Sept.– Oct., 1985. The selected AR_l by the MAIC are

AR_0 : $z(t)=0.97432z\ (t-1)$

AR_1 : $z(t)=0.14277z\ (t-1)$

(B) France - Table 2 and Figure 3

The point of time of the structural change for the French france was December, 1980-January, 1981. The selected AR_l by the MAIC are

AR_0 : $z(t)=0.68278z(t-1)+0.22711z(t-2)$

AR_1 : $z(t)=0.92039z(t-1)$

(C) The Netherlands – Table 3 and Figure 4

The exchange rate of the Dutch guilder experienced the most significant structural change in Sept.-Oct., 1985. The selected AR_l by the MAIC are

AR_0 : $z(t)=0.96268z(t-1)$

AR_1 : $z(t)=-0.15273z(t-1)$

(D) West Germany – Table 4 and Figure 5

The exchange rate of the Deutsche mark experienced the most significant structural change at the same point of time as the Dutch guilder did, i.e., Sept.-Oct., 1985. The selected AR_l by the MAIC are

AR_0 : $z(t)=0.96506z(t-1)$

AR_1 : $z(t)=-0.08381z(t-1)$

(E) Switzerland – Table 5 and Figure 6

The point of time of the structural change for the Swiss franc was earlier than that for the Dutch guilder, the Deutsche mark, and the pound sterling, Dec. 1974–Jan. 1975. The ARi selected by the MAIC are

AR_0 : $z(t)=0.47747z(t-1)$

AR_1 : $z(t)=0.96672z(t-1)$

14. The data are shown in Figures 2 through 8 for the period of Jan., 1973 - Sept., 1986. However, as mentioned earlier, AIC is calculated since January, 1974.

15. In those tables, the first line is a possible point of time M (month and year) of structural break, the second line the calculated AIC for (t_0, M) (i. e., AIC_0), the third line that for (M, t_N) (i.e.,AIC_1), and the last line the sum, i.e., $AIC_M=AIC_0+AIC_1$. According to the MAIC method, the point of time M* that minimizes AIC_M should be chosen. Details

Table 1 The United Kingdom

	12.74	6.75	12.75	6.76	12.76	3.77
AIC_0	−73.581	−101.701	−132.281	−160.672	−195.058	−214.433
AIC_1	−787.510	−763.122	−724.227	−664.248	−609.838	−586.957
AIC_M	−861.091	−864.823	856.508	−824.920	−804.896	−801.390

	6.77	7.77	12.77	1.78	6.78	9.78
AIC_0	−234.123	−239.241	−253.109	−255.235	−301.845	−308.951
AIC_1	−566.052	−559.029	−553.781	−544.773	−509.130	−507.751
AIC_M	−800.175	−798.270	−806.890	−800.008	−810.975	−816.702

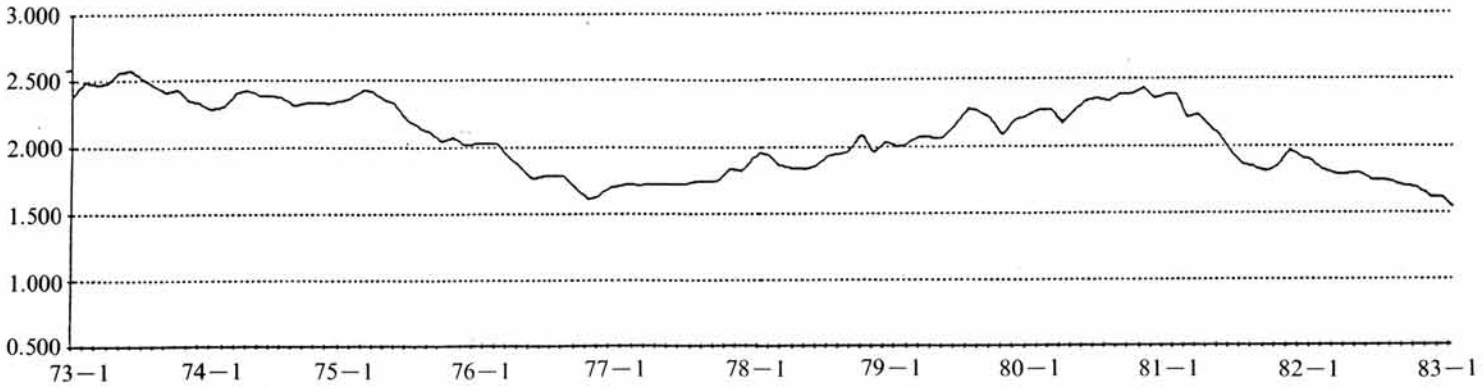
	12.78	2.79	6.79	8.79	10.79	12.79
AIC_0	−317.160	−333.234	−342.394	−345.979	−385.642	−375.862
AIC_1	−482.889	−477.232	−466.876	−453.215	−446.104	−434.558
AIC_M	−800.049	810.466	−809.270	−799.194	−831.746	−810.420

	6.80	12.80	2.81	6.81	9.81	12.81
AIC_0	−399.582	−441.855	−465.951	−482.875	−492.143	−518.762
AIC_1	−395.263	−341.389	−345.545	−359.848	−339.777	−318.175
AIC_M	−794.845	−783.244	−811.496	−842.723	−831.920	−836.937

	1.82	5.82	6.82	12.82	6.83	12.83
AIC_0	−523.208	−544.896	−547.028	−580.330	−615.615	−655.389
AIC_1	−318.346	−294.812	−286.538	−262.366	−221.619	−185.814
AIC_M	−841.554	−839.708	−833.566	−842.696	−837.234	−841.203

	6.84	12.84	6.85	9.85	12.85
AIC_0	−689.319	−710.686	−775.179	−797.748	−816.949
AIC_1	−150.902	−115.882	−97.290	−76.131	−53.732
AIC_M	−840.221	−826.568	−872.469	−873.879	−870.681

Figure 2 The United Kindom : Monthly observations of the U. S. dollar / pound sterling spot exchange rate



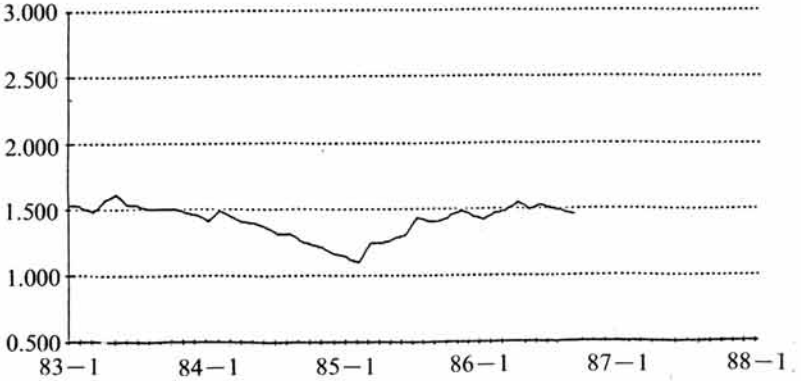


Table 2 France

	12.74	6.75	12.75	6.76	12.76	3.77
AIC_0	−52.074	−81.407	−88.980	−109.116	−131.233	−145.747
AIC_1	−365.966	−344.543	−319.532	−285.799	−259.139	−247.117
AIC_M	−418.040	−425.950	−408.512	−394.895	−390.372	−392.864

	6.77	7.77	12.77	1.78	6.78	9.78
AIC_0	−160.843	−165.948	−188.671	−194.487	−200.661	−228.842
AIC_1	−236.742	−232.282	−216.610	−212.384	−215.830	−194.043
AIC_M	−397.585	−398.230	−405.281	−406.871	−416.491	−422.885

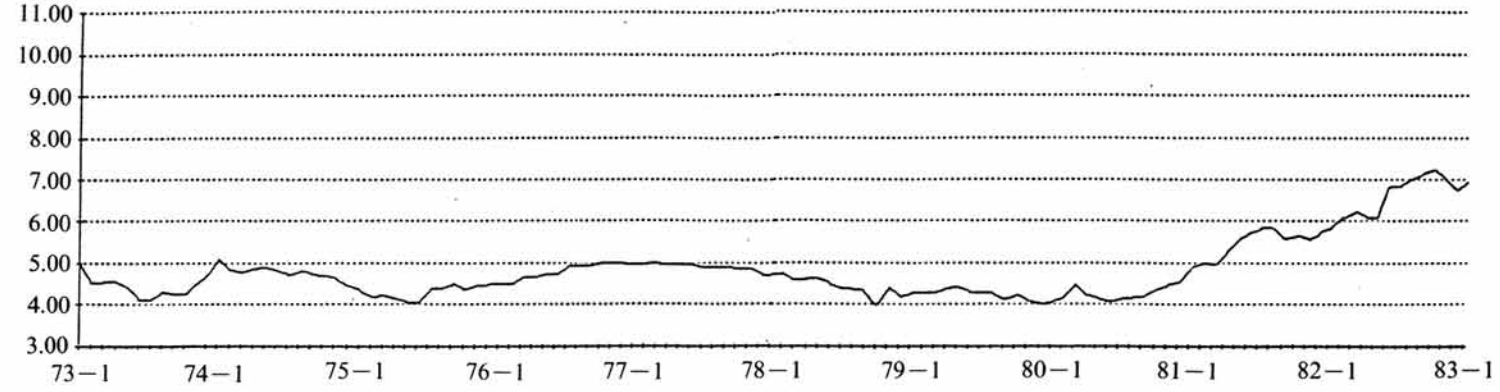
	12.78	2.79	6.79	8.79	10.79	12.79
AIC_0	−229.638	−246.434	−268.512	−276.906	−285.120	−290.117
AIC_1	−185.245	−179.001	−166.931	−160.834	−154.905	−148.887
AIC_M	−414.883	−425.435	−435.443	−437.740	−440.025	−439.004

	6.80	12.80	2.81	6.81	9.81	12.81
AIC_0	−316.332	−342.560	−322.880	−297.351	−322.554	−330.325
AIC_1	−131.457	−121.694	−116.140	−114.535	−103.712	−96.774
AIC_M	−447.789	−464.254	−439.020	−411.886	−426.266	−427.099

	1.82	5.82	6.82	12.82	6.83	12.83
AIC_0	−326.640	−335.968	−293.079	−332.510	−318.520	−319.074
AIC_1	−96.430	−96.413	−93.289	−76.250	−72.665	−63.652
AIC_M	−423.070	−432.381	−386.368	−408.760	−391.185	−382.726

	6.84	12.84	6.85	9.85	12.85
AIC_0	−340.116	−325.311	−363.449	−387.362	−390.953
AIC_1	−51.209	−47.442	−42.297	−33.133	−24.555
AIC_M	−391.325	−372.753	−405.746	−420.495	−415.508

Figure 3 France : Monthly observations of the French franc / U. S. dollar spot exchange rate



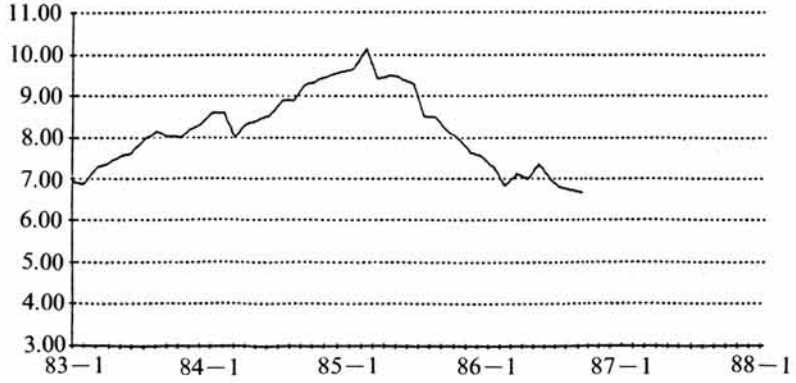


Table 3 The Netherlands

	12.74	6.75	12.75	6.76	12.76	3.77
AIC_0	−59.076	−97.280	−108.929	−140.948	−175.206	194.800
AIC_1	−832.693	−589.745	−549.783	−505.504	−479.604	−465.455
AIC_M	−691.769	−687.025	−658.712	−646.452	−654.810	−660.255

	6.77	7.77	12.77	1.78	6.78	9.78
AIC_0	−214.117	−220.055	−245.845	−252.413	−287.374	−302.827
AIC_1	−447.529	−440.868	−420.016	−417.306	−389.680	−379.322
AIC_M	−661.646	−660.923	−665.861	−669.719	−677.054	−682.149

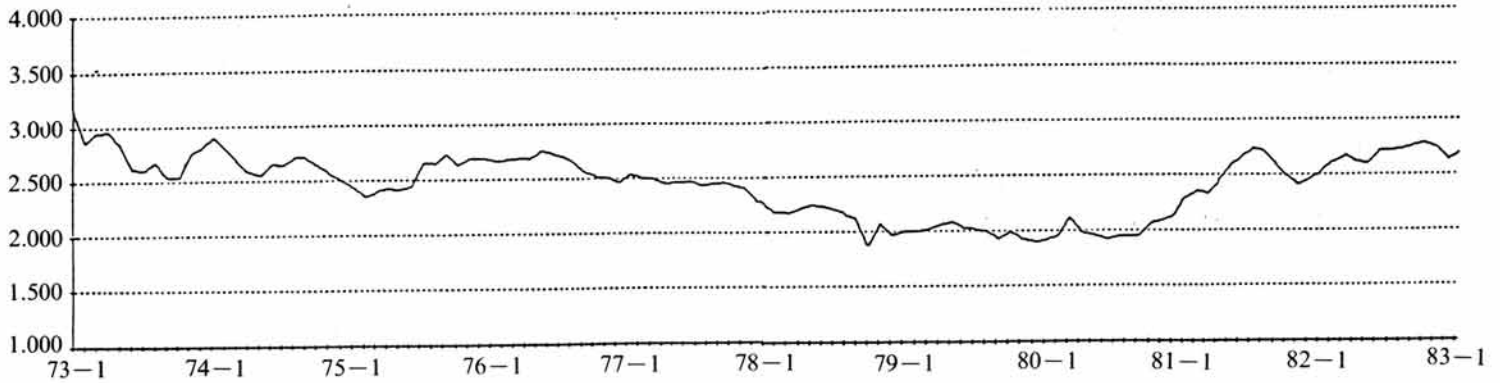
	12.78	2.79	6.79	8.79	10.79	12.79
AIC_0	−304.522	−318.131	−345.851	−358.554	−369.842	−380.032
AIC_1	−367.885	−357.941	−338.278	−327.486	−318.013	−307.962
AIC_M	−672.407	−676.072	−684.129	−686.040	−687.855	−687.994

	6.80	12.80	2.81	6.81	9.81	12.81
AIC_0	−410.126	−435.204	−421.343	−407.909	−435.279	−463.575
AIC_1	−280.615	−264.180	−255.403	−245.212	−228.259	−215.787
AIC_M	−690.741	−699.384	−676.746	−653.121	−663.538	−679.462

	1.82	5.82	6.82	12.82	6.83	12.83
AIC_0	−462.923	−480.858	−472.714	−519.466	−543.327	−548.296
AIC_1	−213.555	−198.172	−193.208	−164.400	−144.803	−124.219
AIC_M	−676.478	−679.030	−665.922	−683.866	−679.130	−672.515

	6.84	12.84	6.85	9.85	12.85
AIC_0	−570.801	−565.357	−608.431	−640.591	−654.084
AIC_1	−101.351	−93.282	−75.323	−59.888	−44.967
AIC_M	−672.152	−658.639	−683.754	−700.479	−699.051

Figure 4 The Netherlands : Monthly observations of the Dutch guilder / U. S. dollar spot exchange rate



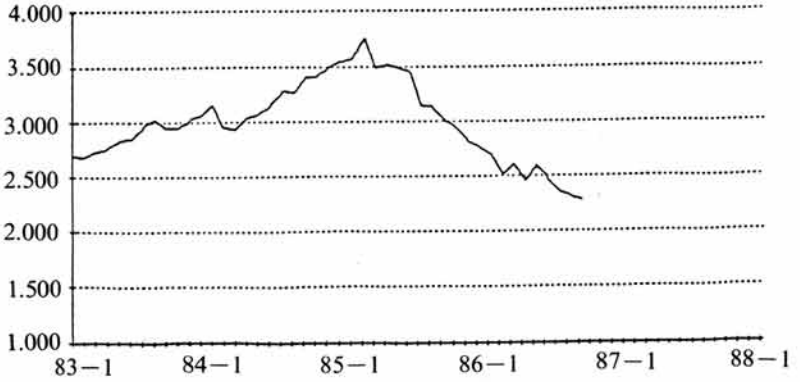


Table 4 West Germany

	12.74	6.75	12.75	6.76	12.76	3.77
AIC_0	−58.123	−97.747	−109.692	−144.801	−179.573	−199.345
AIC_1	−666.748	−618.766	−574.559	−535.232	−504.129	−488.063
AIC_M	−724.871	−716.513	−684.251	−680.033	−683.702	−687.408

	6.77	7.77	12.77	1.78	6.78	9.78
AIC_0	−218.337	−223.499	−247.504	−255.743	−290.980	−305.477
AIC_1	−472.704	−464.189	−444.750	−441.927	−413.332	−402.507
AIC_M	−691.041	−687.688	−692.254	−679.670	−704.312	−707.984

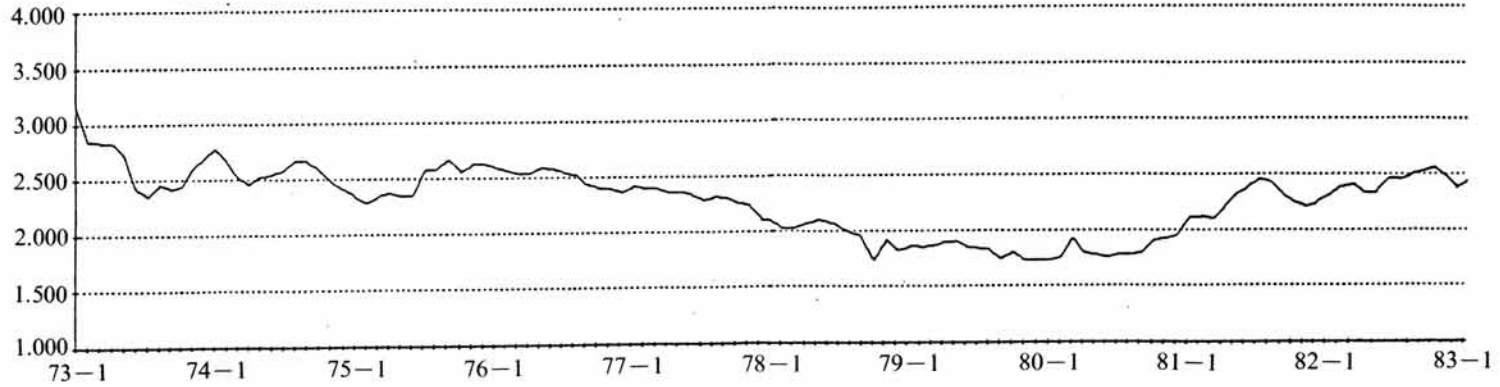
	12.78	2.79	6.79	8.79	10.79	12.79
AIC_0	−309.069	−324.238	−351.713	−365.104	−376.216	−387.105
AIC_1	−390.120	−379.689	−358.871	−347.236	−337.026	−326.909
AIC_M	−699.189	−703.927	−710.584	−712.340	−713.242	−714.014

	6.80	12.80	2.81	6.81	9.81	12.81
AIC_0	−417.047	−440.631	−431.696	−422.186	−448.936	−474.585
AIC_1	−299.501	−282.915	−272.101	−261.767	−243.861	−230.909
AIC_M	−716.548	−723.548	−703.797	−683.953	−692.797	−705.494

	1.82	5.82	6.82	12.82	6.83	12.83
AIC_0	−474.644	−495.150	−486.701	−533.296	−552.525	−568.680
AIC_1	−228.528	−211.957	−206.821	−177.959	−155.573	−133.052
AIC_M	−703.172	−707.107	−693.527	−711.255	−708.098	−701.732

	6.84	12.84	6.85	9.85	12.85
AIC_0	−593.592	−58.151	−633.285	−668.540	−684.492
AIC_1	−108.880	−98.965	−78.574	−62.120	−45.911
AIC_M	−702.472	−687.116	−711.859	−730.660	−729.503

Figure 5 West Germany : Monthly observations of the Deutsche mark / U.S. dollar spot exchange rate



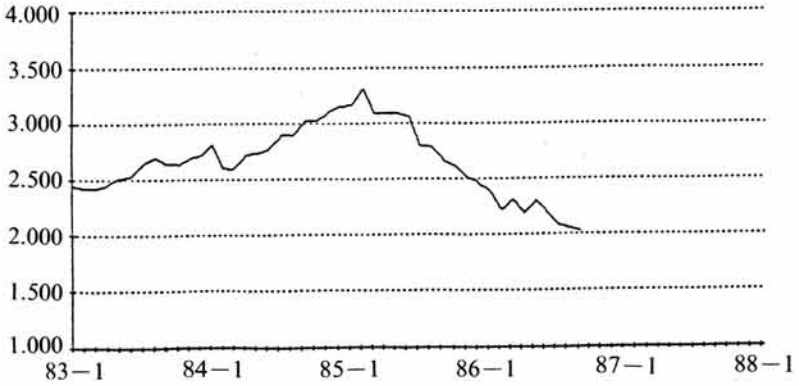


Table 5 Switzerland

	12.74	6.75	12.75	6.76	12.76	3.77
AIC_0	−53.657	−89.245	−104.228	−137.482	−169.751	−181.515
AIC_1	−684.209	−629.986	−595.605	−561.567	−511.661	−486.608
AIC_M	−737.866	−719.231	−699.833	−699.049	−681.412	−668.123

	6.77	7.77	12.77	1.78	6.78	9.78
AIC_0	−199.320	−205.589	−226.098	−233.06	−265.178	−269.542
AIC_1	−473.937	−467.229	−464.796	−464.122	−439.036	−422.711
AIC_M	−673.257	−672.818	−690.894	−697.128	−704.214	−692.253

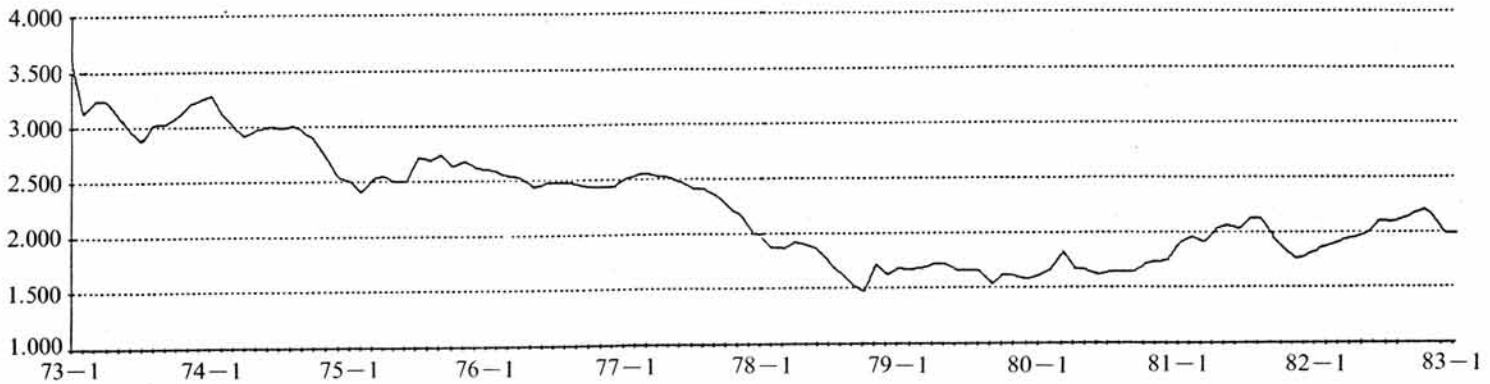
	12.78	2.79	6.79	8.79	10.79	12.79
AIC_0	−291.164	−305.349	−329.415	−341.207	−349.992	−362.049
AIC_1	−145.602	−404.736	−382.968	−370.182	−362.469	−352.385
AIC_M	−706.766	−710.085	−712.383	−711.389	−712.461	−714.407

	6.80	12.80	2.81	6.81	9.81	12.81
AIC_0	−384.876	−404.614	−393.284	−405.789	−424.180	−450.425
AIC_1	−324.583	−303.152	−292.989	−275.102	−257.873	−242.500
AIC_M	−709.459	−707.766	−686.273	−680.891	−682.053	−692.925

	1.82	5.82	6.82	12.82	6.83	12.83
AIC_0	−451.934	−459.010	−453.233	−491.770	−513.105	−537.117
AIC_1	−239.306	−226.487	−220.998	−188.609	−162.582	−136.202
AIC_M	−691.240	−685.497	−674.231	−680.379	−675.687	−673.319

	6.84	12.84	6.85	9.85	12.85
AIC_0	−553.080	−558.851	−589.497	−623.294	−641.588
AIC_1	−116.078	−103.478	−91.046	−69.766	−48.745
AIC_M	−669.158	−662.329	−60.543	−693.060	−690.333

Figure 6 Switzerland: Monthly observations of the Swiss franc / U.S. dollar stop exchange rate



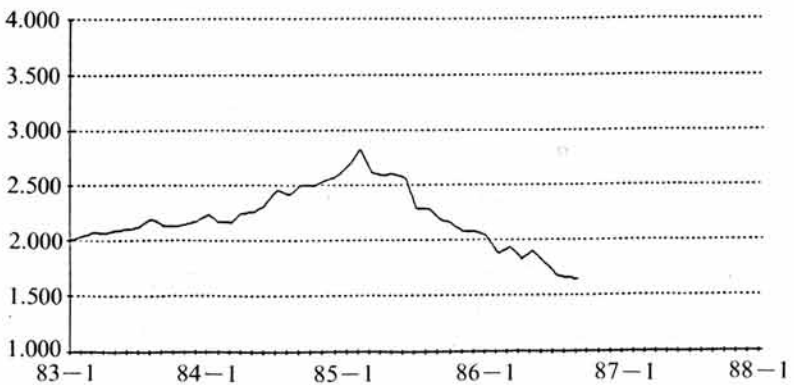


Table 6 Japan

	12.74	6.75	12.75	6.76	12.76	6.77
AIC_0	51.880	71.209	86.191	99.508	116.731	151.622
AIC_1	614.315	596.796	590.203	572.695	559.039	530.480
AIC_M	666.195	667.905	676.394	672.203	675.770	682.102

	12.77	6.78	9.78	12.78	6.79	12.79
AIC_0	190.169	236.564	251.631	308.276	264.838	301.951
AIC_1	501.636	480.344	476.963	445.737	413.349	381.065
AIC_M	691.805	716.908	728.594	754.013	678.187	683.016

	6.80	11.80	12.80	6.81	12.81	6.82
AIC_0	310.549	331.498	334.992	368.021	393.557	451.421
AIC_1	354.995	343.426	338.562	294.110	267.787	225.673
AIC_M	665.544	674.924	673.554	662.131	661.344	677.094

	12.82	6.83	12.83	6.84	12.84	6.85
AIC_0	458.220	483.232	498.656	524.233	556.687	572.909
AIC_1	196.761	168.598	146.649	117.047	80.351	56.147
AIC_M	654.981	651.830	645.305	641.280	637.038	629.056

	9.85	12.85
AIC_0	575.980	590.501
AIC_1	38.440	26.573
AIC_M	614.420	617.074

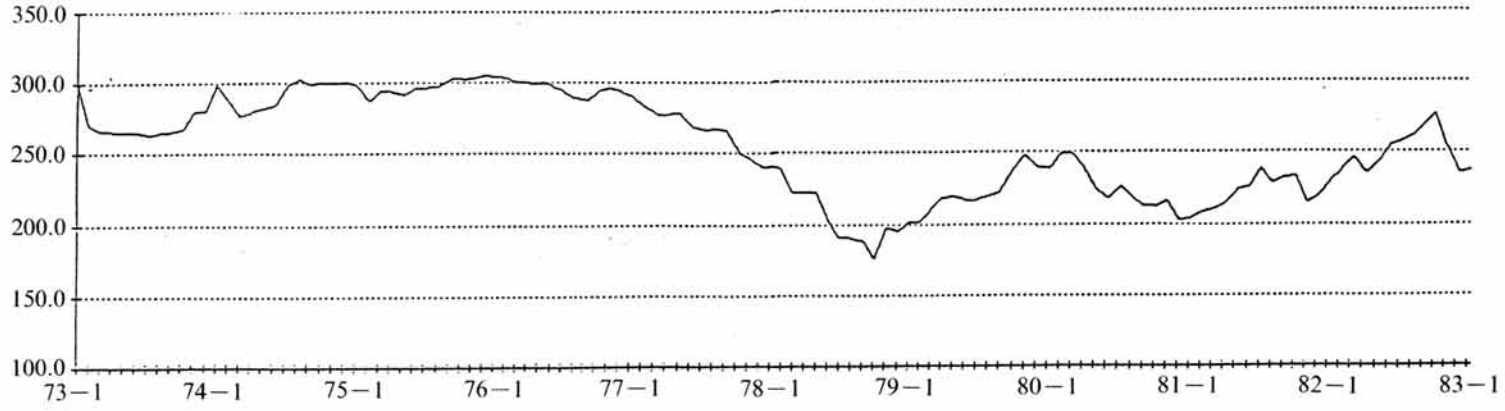
(F) Japan – Table 6 and Figure 7

The exchange rate of the Japanese yen experienced the most significant structural change in Sept.–Oct., 1985, same as the pound sterling, the Dutch guilder, and the Deutsche mark did. The AR_1 selected by the MAIC are

AR_0 : $z(t)=0.95923z(t-1)$

AR_1 : $z(t)=-0.01935z(t-1)$

Figure 7 Japan : Monthly observations of the Japanese yen / U.S. dollar spot exchange rate



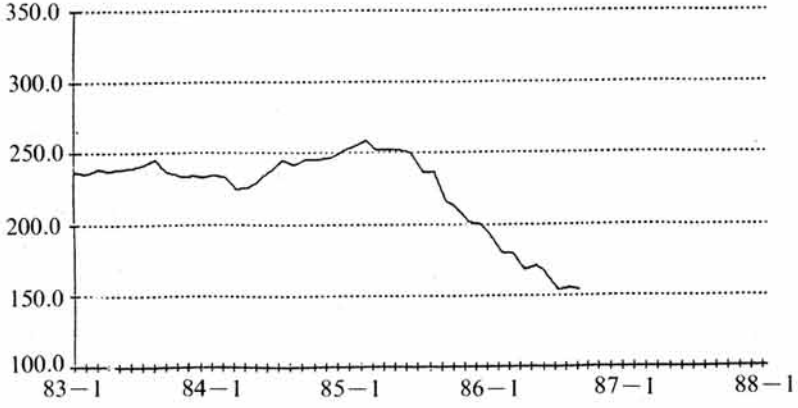


Table 7 Canada

	12.74	6.75	12.75	6.76	12.76
AIC_0	−109.775	−164.725	−222.951	−366.267	−306.508
AIC_1	−1171.286	−1113.271	1063.168	−998.392	−965.687
AIC_M	−1281.061	−1277.996	−1286.149	−1264.659	−1272.195

	6.77	12.77	6.78	12.78	6.79
AIC_0	−358.741	−400.783	−453.353	−491.691	−547.949
AIC_1	−918.853	−869.453	−814.694	−750.231	−715.368
AIC_M	−1277.594	−1270.236	−1268.047	−1241.922	−1263.317

	12.79	6.80	12.80	6.81	12.81
AIC_0	−600.618	−638.862	−700.472	−755.004	−793.417
AIC_1	−667.695	−624.714	−567.647	−509.695	−470.987
AIC_M	−1268.313	−1263.576	−1268.119	−1264.699	−1264.404

	6.82	12.82	6.83	12.83	6.84
AIC_0	−835.329	−887.422	−939.535	−997.584	−1050.866
AIC_1	−424.689	−379.632	−288.552	−268.839	−221.500
AIC_M	−1260.018	−1267.054	−1228.087	−1266.423	−1272.368

	12.84	6.85	9.85	12.85
AIC_0	−1106.274	−1145.680	−1172.651	−1195.271
AIC_1	−168.662	−125.745	−98.159	−76.498
AIC_M	−1274.936	−1271.425	−1270.810	−271.769

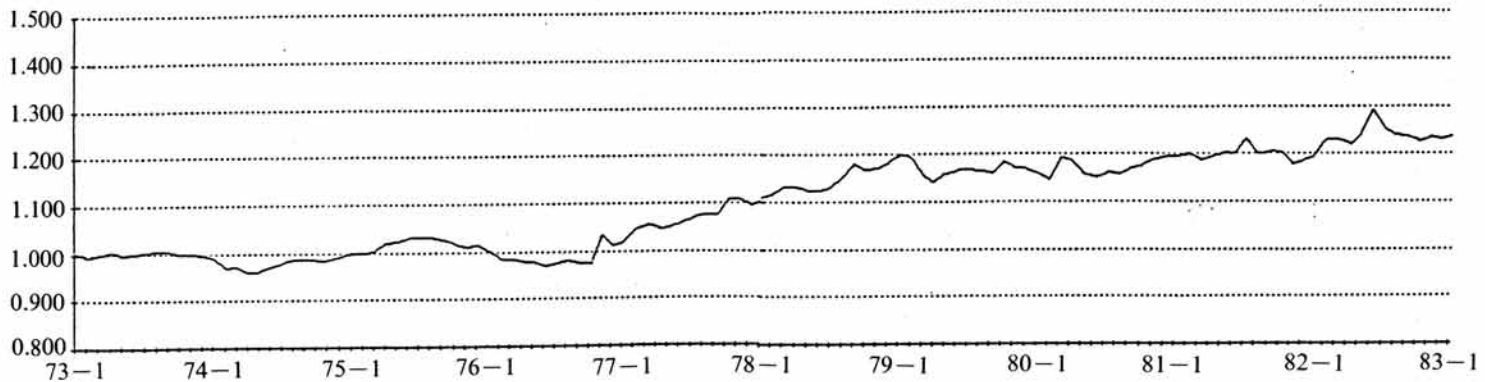
(G) Canada− Tabel 7 and Figure 8

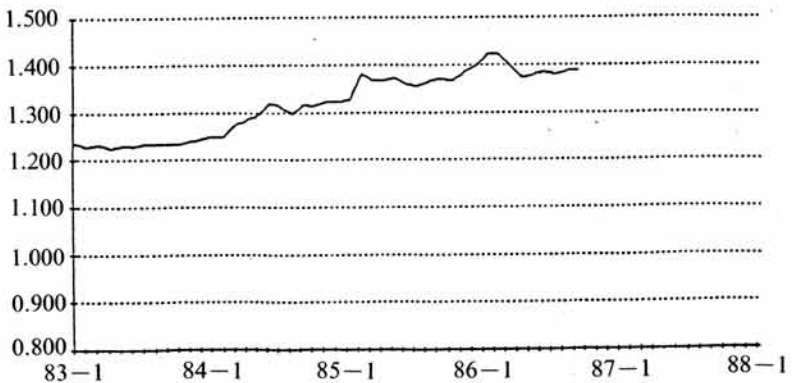
Table 7 shows that the computed AIC for the exchange rate of the Canadian dollar has been fluctuating within a relatively narrow range. However, according to the AIC_M, it could be judged that a relatively significant structural change occurred in Dec. 1975 - Jan. 1976. The AR_1 selected by the MAIC are

AR_0 : $z(t)=0.59177z(t-1)$

AR_1 : $z(t)=0.86773z(t-1)$

Figure 8 Canada : Monthly observations of the Canadian dollar / U.S. dollar spot exchange rate





Since the points of time, M*, that optimally cut off $\{z(t)\}$ for seven major currencies are determined by the purely statistical technique - the MAIC, they will be tested by a traditional method of detecting structural change in the next section.

Ⅳ. An Alternative Test of Structural Change

The points of time of structural change for the seven major exchange rates are identified by utilizing a new application of the MAIC method in the last section. In order to examine whether those points of time of structural change are dependent on the method employed (or, put differently, whether they are robust for different models), a regression model is assumed in this section.[16] At this point, however, we encounter the problem of which model to choose. Since the exchange rate is nothing but "the relative price of national monies" (Branson (1979), p.190), it could be argued that it is more appropriate to select a model from the asset market approach (i.e., either the monetary model or the portfolio balance model), rather than from the flow approach. However, the matter is not so simple in the flowing two respects ; (1) there is, at present, no single model able to give a better explanation with flexible exchange rates (e.g., Backus (1984), Meese and Rogoff (1983a,b), Frankel(1983), Leventakis (1987), and (2) there is automatically some arbitrariness in selecting explanatory variables, etc. (note that, in contrast, a time-series model is essentially arbitrariness-free in this sense).

Thus, we decided to select the efficiency condition (Roll (1979), Shapiro (1983)) for commodity markets, i.e., the arbitrage condition, for a comparison purpose with the time-series model. If the foreign exchange markets are efficient in open economies, several arbitrage conditions must hold, as shown in Shapiro (1983). One of those efficiency (arbitrage) conditions-the commodity arbitrage-has been referred to as Purchasing Power Parity (PPP, hearafter).

It is well documented that the arbitrage condition (PPP) holds in the long-run. However, it is also well known that the condition does not hold in the recent floating period (e.g., Frenkel (1981)), and that, in the short-run, deviation from the condition essentially follow a random walk (e.g., Adler and Lehmann (1983), and Hakkio (1984)), Thus, the arbitrage condition is stated as the long-run equilibrium condition as follows:

$$/n\ \bar{S}_t=\alpha+\beta(/n\ P_t-/n\ P_t^*) \qquad (8)$$

16. This section draws in part on Akiba (1988).

where S_t=the spot exchange rate, defined as units of the domestic currency per unit of the foreign currency at time t

P_t=the domestic price level.

The bar(−) over the variable means the long-run equilibrium value, and the asterisk (*) the foreign country(i.e., the U.S.).

If we accept the argument of Frenkel (1983) that divergences from the arbitrage condition in the short-run actually reflect equilibrating changes, it is possible to write:

$$/n S_t - /n S_{t-1} = \lambda(/n \bar{S}_t - /n S_{t-1}) \tag{9}$$

where λ is the partial adjustment coefficient that indicates the speed at which deviations from the arbitrage condition are corrected through time. The reasons for assuming equation (9) are, as Frenkel (1983) observes, that there are continuous changes in real economic conditions that require adjustment in the equilibrium relative prices of different national outputs, and that the prices of national outputs do not anjust fully to shocks in the short-run. [17]

Combining equations (8) and (9), the following expressions is obtained:

$$/n\ S_t = \alpha\lambda + \beta\lambda(/n P_t - /n P_t^*) + (1-\lambda)/n S_{t-1} \tag{10}$$

Under the hypothesis that the arbitrage condition (PPP) holds in the long-run, β (the long-run elasticity) should not differ from unity. On the other hand, $\beta\lambda$ (the short-run elasticity of the exchange rate with respect to the price ratio) will be significantly lower than unity if there are short-run deviations from the arbitrage condition.

Equation (10) is estimated by OLS, with a stochastic disturbance with desirable characteristics, for the seven exchange rates. The largest sample is monthly observation (end of month) of the French franc exchagne rate from January, 1973 through December, 1987(180 samples), and the smallest one is that of the Japanese yen rate through July, 1987 (175 samples), depending on data availabiliy at the time of estimation. Monthly observations of the wholesale price index are selected as P and P^* for all exchange rates except the French franc rate(where the consumer price indices were used because of non-availabiliy of WPI data).

The estimated results are not reported here because they are not particulary impressive

17. See also Bhandari (1983) and Woo (1985) for the delay in full response to shocks in the short-run.

as expected from accumulated evidence on PPP, and because our main concern is whether a significant structural change occurs at each point of time identified in the last section for each exchange rate.[18]

Since particular points of time when structural changes are suspected to occur are at hand, it is a rather simple matter to calculate the F statistics for an appropriate traditional test of structrual change (the Chow test). The test is performed under the null hypothesis that there exists the equality of regression coefficients of two equations (one with the first M observations and the other with the remaining $t_N - M$ observations, i.e., before and after the supected point of time of structural change, M.) The calculated F statistics are summarized in Table 8.

Table 8 A Traditional Test of Structural Change

Exchange rates	Suspected points of time of structural change	Calculated F−values*
The United Kingdom	Sept.−Oct., 1985	1.02
France	Dec., 1980−Jan., 1981	7.25[(a)]
The Netherlands	Sept,−Oct., 1985	3.20[(a)]
West Germany	Sept, −Oct., 1985	3.09[(a)]
Switzerland	Dec., 1974−Jan., 1975	2.73[(b)]
Japan	Sept,−Oct., 1985	5.06[(a)]
Canada	Dec., 1975−Jan., 1976	2.0

Remarks : *=calculated from estimates of equation (10)

The null hypothesis of no structural break is rejected at the significance level of (a) one percent and (b) five percent.

The critical value of F is 2.60 at the five percent, and 3.78 at the one percent level of significance. Thus, it is confirmed that those suspected points of time are in fact breakpoints except the Canadian dollar and the pound sterling rates.

The peculiarity of the Canadian dollar rate was expected, because, as hinted in the last section, the computed AIC has been fluctuating within a relatively narrow

18. The estimated results are available for interested readers on request.

range. Moreover, Daniel (1986, p.322) argues that "[t] his abnormality for the Canadian case could be due to attempts by the Canadian central bank, ···, to peg the Canadian dollar to the U.S. dollar. The U.S.−Canadian equations should fail under this kind of central bank intervention."

Also it would not necessarily be surprising to find that the sterling pound rate equation did not confirm the same breakpoint as an AR model did. In fact, in a recent empirical study, Edison (1987, p.385) concludes that. "the PPP relationship does not adequately represent the dollar/pound exchange rate."

These observations may reconfirm our previous remark at the outset of this section about difficulty of selecting an appropriate structural model.

V. Discussion

Turning to our main concern of detecting points of time of structural change by our new application method of the MAIC, several comments are in order.

First of all, technically speaking, we are concerned only with an AR model in this paper. If u(t) in equation (3) is not white noise, we could have used an ARMA model. However, we did not employ an ARMA model, but an AR model, for our investigation. We did this because the MA part of the ARMA model can not only be interpreted easily from an economic point of view, but also because practically an ARMA model can not alwalys assure a better estimation than an AR model.[19]

Secondly, our method (which is nothing but an application of AIC one more step further) can identify whether and when one structural change occurred within a process. If there are several structural changes in a process, we could develop another application of Ozaki and Tong's (1975) method, which is essentially a piecewise application method of AIC.[20] The application method of the AIC employed in this paper was devised by us in order to identify a turning point within a process, and it is the most useful if the process is divided into two subprocesses with different characteristics.

Our calculation results for Canada, Table 7, in which it is difficult to find a distinct turning point, may be related to this problem. In other words, it could be argued,

19. See footnote 3 which also explains a technical reason for lesser data for an AR model.

20. Several points of time of structural change could be identified by the piecewise method. However, such a method would violate the essential requirement of having a sufficient number of observations to estimate an AR model because of fractionarizing data. A generalized application method is explained in footnote 9.

as in section III, that a structural change occurred at a distinct point of time; or, it could also be asserted that structural changes have occurred continuously for the Canadian dollar case. If either interpretation is correct, our calculation indirectly renders support to Backus (1984) and concludes that a possible reason for the poor performances of all existing regression models could be their failure to take structural changes into consideration appropriately for the Canadian dollar case.[21]

The third point is in a sense more subtle. Even though we could conclude that each foreign exchange rate for the seven major currencies underwent a structural change at time M*, it would not be so clear from which side of the exchange rate strctural change occurred. In other words, since the exchange rate is nothing but a relative price of two monies, a structural change of £/$ rate, for example, occurs either with the pound sterling or with the U.S. dollar, or with both. For the exchange rate of the pound sterling, Deutsche mark, Dutch guilder, and Japanese yen vis-à-vis the U.S. dollar, the most signiticant structural change occurred at the point of time of the coordinated interventions by the G-Five nations (Sept., 1985), according to our MAIC method. However, the exchange rate of the French franc did not show a significant structural change at this point of time, although France is a member of the G-Five nation. Moreover, since other two exchange rates (the Swiss franc and the Canadian dollar) also did not show a significant structural change at this point of time, we could safely interpret either that, even if we exclude the period of substantial intervention such as the G-Five nations (Sept., 1985), structural change occurred in each of seven countries (not in the standard country, i.e., the United States), or that structural changes for the seven currencies outweighed that for the United States.

Fourthly, each AR model, AR_0 and AR_1, should be estimated with a sufficient number of data, in order to make the estimators reliable. Actually, in our another experiment (Waragai and Akiba (1986)), we set 38 data as a criterion for a minimum number of observation. However, in the present investigation, we are particularly interested in the effect of intervention by the G-Five nations since September, 1985. If the data are cut off at this point of time, then AR_1 should be calculated with only 12 observations (from Oct., 1985 to Sept., 1986). Thus, we did not impose such a restriction of number of observations (as we did in our previous investigation) in order to examine the effectiveness of intervention by the G-Five nations.

21. See also the last section, quoting Daniel's argument to suggest that a possible cause of peculiar movement of AIC for the Canadian dollar may be due to heavy intervention by the Canadian central bank.

Finally, the background in the real-world foreign exchange markets around the time when AIC took its minimum is briefly reviewed in the rest of this section. It should be stressed that we merely point out what was happening at M* for each exchange rate, and have *in no way any intention of suggesting any possible cause* of strutural changes.

In the period from September to October, 1985, the exchange rates of the Deutsche mark, pound sterling, Dutch guilder and Japanese yen underwent the most significant structural change according to AIC_M^*. The result is exactly what we have expected.

In 1985 a period of strong US dollar since 1980 came to an end. Trade imblance in the U.S. with major countries—especially Japan—has kept on expanding, and in the spring it was getting apparent that the U.S. would experience a recession and become a debtor country. Under the circumstances, a decline in the U.S. dollar was anticipated, and the actual spot rates began to depreciate since then.

In September, a conference of the G-Five nations was held, at the same time as a surge in protectionism in the U.S. Congress. As a result, policy measures of coordinated intervention operation (sales of the U.S. dollar) and of the higher rate of interest in Japan accelerated the dollar downward movement. The exchange rates of four currencies mentioned above moved up against the U.S. dollar since Sept., 1985.

The other three currencies (the French franc, the Swiss franc, and the Canadian dollar) did not seem to be affected strongly by this intervention operation.[22]

In the period from December, 1980 to January, 1981, when the French franc/dollar rate experienced the most significant structural change, the rate was depreciating. It could be argued that the French franc/dollar rate experienced a structural change in mid-1981 when the Socialist party took power. However, according to AIC_M, the M^* was earlier by five to six months than the time of the change of government(see Figure

22. Although the French franc seemed to experience a significant structural change at the time of intervention by the G-Five nations, a much stronger change around Dec., 1980-Jan., 1981 was detected by our MAIC method. After the agreement by the G-Five nations, the French franc kept stable because (1) the French government had a firm intention to avoid a depreciation by all means until the general election in March, 1986, and (2) a favorable turn of the French economy was expected because of an improved condition for anti-inflation with a fall in the oil price and a depreciation of the U.S. dollar.

It has been argued that the yen/dollar rates experienced a structural change on December 18, 1980 when the Japanese government deregulated almost all foreign exchange controls. However, our calculation shows that the M^* was earlier by six months than the deregulated time.

3).[23]

The Swiss franc/dollar rates experienced the most significant structural change around Dec., 1974–Jan., 1975, according to the AIC_M. Since November, 1974 the Swiss franc rates appreciated rapidly, and the Swiss government strengthened the restriction of paying interest on deposits by non-residents. However, the Swiss franc/dollar rate kept appreciating, and the Swiss government sounded out the possibility for their being a member of the European joint float system. Their intention was not realized because of an objection by the French government. Our calculation of AIC_M showed that the Swiss franc/dollar rates experienced the most significant structural change around this time.

The Canadian dollar/U.S. dollar rates experienced the most significant structural change around Dec., 1975–Jan, 1969 although the computed AIC has been fluctuating within a relatively narrow range. The Canadian dollar rates were appreciating steadily since August, 1975, but Euro-Canadian dollar bonds were issued in large quantities towards the end of 1975. Moreover, in January, 1976, an increase in the demand for the Canadian dollar by foreign importers of Canadian grains and a fall in the interest rate in the U.S. led the Canadian dollar rates to appreciate against the U.S dollar. Our calculation of AIC_M showed that the Canadian dollar/U.S. dollar rates experienced the most significant structural change around this period as a turning point to depreciation since then.

Ⅵ. Conclusions

The main purpose of this paper is to find out the particular point of time when exchange rates of seven major currencies vis-à-vis the U.S. dollar underwent a structural change in the recent floating period, in view of the poor out-of-sample forecasts reported by Meese and Rogoff(1983a, 1983b), Backus (1984), Finn (1986), Hakkio (1986), and Somanath (1986). Our calculation results of the particular point of time when those exchange rates experienced structural changes are reported in Tables 1 to 7, compared

23. When other European currencies tended to depreciate after a rising of the U.S. interest rates im March-April, 1980, the French franc did not depreciate as much as Deutsche mark did. In October, 1980, the French franc/Deutsche mark rate reached its upper limit, and the French authorities intervened in the market frequently. However, since the depreciation of the Deutsche mark tended to continue, they adopted several supporting measures for the Deutsche mark in November, 1980. These measures were taken to discourage and prevent the inflow of short-term capital temporarily.

with results of the traditional test in section IV. and discussed in some details in section V. For the Canadian dollar rate our calculation suggests that the foreign exchange market has experienced these changes intermittently, supporting Backus' conclusion (1984). [24]

Technically speaking, our approach, the MAIC method, has two distinct advantages over the traditional approaches. First of all, we can avoid any arbitrariness in two respects; (1) arbitrariness of determination of the significance levels, since the MAIC method is a powerful alternative to the test of the hypothesis method, and (2) abrit−rariness arising from specification of regression models, since only a time series model is employed. Secondly, since the MAIC method has been employed extensively in time series analyses, our method is a straight-forward application of it which brings it one more step further to detecting structural changes.

In economics it is important to make a clear distinction between transitory (or fluctuating) factors and semi-permanent (or relatively constant) factors. Economic analysis of the former factors would be difficult (or impossible) if structural changes were ignored, since the "structure" is essentially a semi-permanent factor. This point was emphasized by Keynes (1973) some fifty years ago:

> "Economics is a science of thinking in terms of models···. The object of a model is to segregate the semi-permanent or relatively constant factors from those which are transitory or fluctuating so as to develop a logical way of thinking about the latter, and of understanding the time sequences to which they give rise in particular cases" (pp. 296-7)

Since the particular points of time of structural changes are idenified for most

24. We also considered the case where there is no structural change in our model and calculated its AIC. The AIC_M. is compared with AIC_A (with all data, assuming no structural change) as follows:

	AIC_A	AIC_{M*}
West Germany	−729.503 >	−730.660
Japan	617.074 >	614.420
The Netherlands	−699.051 >	−700.479
France	−415.508 >	−464.25
Switzerland	−690.333 >	−737.866
The United Kingdom	−870.681 >	−873.879
Canada	−1271.769 >	−1286.149

Thus, we can reject a hypothesis that there exists no structural change within the sample period.

currencies, such information would give regression models more explanatory power. It would also increase the higher accuracy of out-of-sample predictions, if they are constructed to take such structural changes into consideration and to regress on the divided sample periods.

References

Adler, Michael and Lehman, Bruce (1983), "Deviations form Purchasing Power Parity in the Long Run." *Journal of Finance*, Vol. 38, No.5 (Dec.) pp.1471−1487.

Akaike, H. (1973), "Information Theory and an Extention of the Maximum Likelihood Principle," in B.N. Petrov and F. Kaski (eds.) *2nd International Symposium on Information Theory*. Budapest : Akademiai Kiado.

Akaike, H. (1974), "A New Look at the Statistical Model Identification," *IEEE Trans. on Automatic Control*, AC-19-6, pp.716−723.

Akiba, Hiroya (1988), "Structural Changes in the Yen-Dollar Rate in the Recent Floating Period : January, 1973 through July, 1987," *Asian Journal of Economics and Social Studies* (forthcoming).

Backus, D. (1984), "Empirical Models of the Exchange Rate : Separating the Wheat from the Chaff," *Canadin Journal of Economics*, Vol.17, No.4 (Nov.) pp.824−846.

Bhandari, Jagdeep S.(1983), "Aggregate Dynamics in an Open Economy," *The Manchester School*, Vol. 51, No.2 (June) pp.129−151.

Branson, William H. (1979), "Exchange Rate Dynamics and Monetary Policy," chapter 8 of Assar Lindbeck (ed.) *Inflation and Employment in Open Economy* (Studies in International Economics, No.5.) Amsterdam : North-Holland Pub. Co., pp.189−224.

Daniel, Betty C. (1986), "Empirical Determination of Purchasing Power Parity Deviations " *Journal of International Economics*, Vol.21, pp.312−326.

Davutyan, N. and Pippenger, J. (1985), "Purchasing Power Parity Did Not Collapse During the 1970's," *American Economic Review*, Vol. 75, No.5(Dec.), pp.1151−1158.

Edison, Hali J.(1987), "Purchasing Power Parity in the Long Run : A Test of the Dollar/Pound Exchange Rate (1890−1978)," *Journal of Money, Credit, and Banking*, Vol. 19, No.3(Aug.), pp.376−387.

Finn, M.G. (1986), "Forecasting the Exchange Rate : A Monetary or Random Walk Phenomenon ?" *Journal of International Money and Finace*, Vol.5, pp.181−193.

Frankel, Jeffrey A. (1983), "Monetary and Portfolio-Balance Models of Exchange Rate Determination," chapter 3 in J.S. Bhandari and B.H. Putnam (eds) *Economic Interdependence and Flexible Exchange Rate*. Cambridge, Mass. : The MIT press, pp.84−115.

Frenkel, Jacob A. (1981), "The Collapse of Purchasing Power Parities During the 1970s," *European Economic Review*, Vol. 16, No.1 (May) pp.145−165.

——————— "Monetary Policy : Domestic Target and International Constraints," *American Economic Review*, Vol. 73, No.2 (May) pp.48−53.

Fukuda, T. (1977), "A Method of Rapid Malfunction Diagnosis of Random Processes by Formulation of Autoregressive Modelling," *Theoretical and Applied Mechanics*.

Gregory, A.W. and McCurdy, T. H. (1984) "Testing the Unbiasedness Hypothesis in the Forward Foreign Exchange Market : A Specification Analysis," *Journal of International Money and Finance*, Vol.3, pp.357−368.

Hakkio, C.S. (1984), "A Re-Examination of Purchasing Power Parity : A Multi-Country and Multi-Period Study," *Journal of International Economics*, Vol.17, pp.165−277.

——————— "Does the Exchange Rate Follow a Random Walk ? A Monte Carlo Study of Four Tests for a Random Walk," *Journal of International Money and Finance*, Vol.5, pp.221−229.

Keynes, J.M. (1973), *The Collected Writings of John Maynard Keynes*. XIV, London: Macmillan.

Leventakis, John A. (1987), "Exchange Rate Models : Do They Work ?," *Weltwirtschaftliches Archiv*, Band 123, Heft 2, pp.363−376.

Meese, R. A. and Rogoff, K. (1983a), "Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample ?," *Journal of International Economics*, Vol.14, pp. 3−24.

——————— (1983b), "The Out-of-Sample Failure of Empirical Exchange Rate Models: Sampling Error or Misspecification ?," in J.A.Frenkel (ed.) *Exchange Rates and International Macroeconomics*. Chicago : The Univ. of Chicago Press.

——————— (1985), "Was It Real ? : The Exchange Rate Interest Differential Relation, 1973−1984," International Finance Discussion Paper No. 268 (August), Board of Governors of the Federal Reserve System.

Mussa, M. (1979), "Empirical Regularities in the Behavior of Exchange Rates and Theories of the Foreign Exchange Market," in K. Brunner and A.H. Meltzer (eds.) *Policies for Employment, Prices and Exchange Rates* (Carnegie-Rochester Conference Series on Public Policies, Vol. 11). Amsterdam : North-Holland Pub. Co.

Ozaki, T. and Tong, H. (1975), "On the Fitting of Nonstationary Autoregressive Models

in Time Series Analysis," Proceedings of the 8th Hawaii International Conference on System Sciences," Western Periodical Co.

Rush, Mark and Husted, Steven (1985), "Purchasing Power Parity in the Long-run," *Canadian Journal of Economics*, Vol.18, No. 1(Feb.) pp.137−145.

Sakamoto, Y., Ishiguro, M., and Kitagawa, G. (1983), *Jyohoryo Tokeigaku*. Tokyo: Kyoritsu Shuppan Co., Ltd. (the English translation : *AIC Statistics*. (1986) D. Reidel, Dortrecht, Holland).

Shapiro, Alan C. (1983), "What Does Purchasing Power Parity Mean?" *Journal of International Money and Finance*, Vol.2, pp.295−318.

Somanath, V.S. (1986), "Efficient Exchange Rate Forecasts : Lagged Models Better the Random Walk," *Journal of International Money and Finance*, vol.5, pp. 195−220.

Waragai, Tomoki(1986), "Jikeiretsu ni motozuku Kouzou Henka no Kenshou," *Chochiku Keizai Roron Kenkyukai Nenpou*, Vol.2(July) pp.131−148 (in Japanese) ("Analysis of Structural Change by Time-Series").

Waragai, Tomoki(1987), "Der Einfluss von Reorganizationen auf die Unternehmensentwicklung : Eine Ökonometrische Analyse," Discussion paper No. D−19, University of Bonn.

———————— T. and Akiba, H. (1986), "Structural Change and Time−Series Exchange Rates : Application of AIC to Seven Major Currencies ; Janurary, 1974 October, 1985" (May) (mimeographed).

Woo, Wing T. (1985), "The Monetary Approach to Exchange Rate Determination under Rational Expectations : The Dollar-Deutschemark Rate," *Journal of International Economics*, Vol. 18, pp.1−16.