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Exchange Rate Movements and International Interdependence of Stock Markets

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Abstract

This paper investigates linkages between stock markets in seven industrialized countries since 1974. Empirical evidence shows that both nominal and real stock prices (and returns) are strongly positively correlated across countries, and that nominal exchange rate changes do not have systematic effects on nominal stock prices. A two-country theoretical model is developed and an attempt is made to reconcile the empirical findings with the properties of this model. Independent evidence on the main sources of shocks is used to argue that the time-varying correlation in the data can be reconciled with the predictions of the theory.

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I. Introduction

Close international integration of financial markets is widely regarded as a major contributing factor in the economic interdependence of countries. In particular, shocks in individual countries are thought to be rapidly transmitted to other economies through changes in interest rates and exchange rates. Disturbances of a worldwide nature are incorporated immediately into asset prices in all financial centers, and economic activity in the countries of a financially integrated area can be influenced almost simultaneously as firms and households react to the signals incorporated in these asset prices. 1/

Theoretical and especially empirical research on these phenomena has centered on markets for financial assets. Potentially, equally important transmission effects could occur through markets for claims on real assets. Although perhaps less internationally integrated, national equity markets are believed to process information efficiently and thereby to take into account relevant external developments in pricing (of even non-traded) assets. Prices of these assets may in turn have important influences on domestic economic activity through firms' investment decisions or through household spending.

It thus seems of interest to incorporate equity prices into models of open economies and to study empirically, as well as theoretically, how national stock markets are linked and what role they play in the international transmission of shocks. The goal of this paper is to provide a contribution to such an analysis. 2/

Consider Charts 1 and 2 which show the movements of nominal and real stock prices, respectively, in Germany, Japan, and the United States since 1974. 3/ The following questions come to mind:

1/ Indeed, interest parity conditions are central to the transmission mechanisms in the majority of recent open economy macroeconomic models.

2/ Theoretical work incorporating stock market effects in open economy macroeconomic models includes Gavin (1986) and Murphy (1988). The finance literature has of course been concerned with linkages between national stock markets in studies of the benefits of international portfolio diversification. See, for example, the comprehensive survey by Adler and Dumas (1983), which also contains references of empirical evidence on correlation between returns in various markets. Andresen (1988) presents evidence suggesting that common international factors can explain a significant portion of the variation in national stock price indexes and, furthermore, that the same international factors are leading indicators of national business cycles. See also Schwert (1988) for an empirical investigation of stock market volatility.

3/ Real stock prices are defined as the nominal price deflated by the domestic price of goods.

(1) Is it possible to detect common trends in these series, and if so, what factors could explain these trends?

(2) Do the series exhibit stable short- to medium-term relationships, and if so, are these due to common shocks or to the transmission of nation-specific shocks?

(3) In the latter case, is one country dominant in the sense that its stock price changes cause movements elsewhere?, and
(4) Is it true, as the Charts suggest, that stock prices have moved quite closely together in spite of the very large exchange rate changes that have taken place during the same period, and if so, why?

Charts 3 and 4 illustrate some additional puzzles. They show differences in real stock prices between Germany and the United States (Chart 3) and between Japan and the United States (Chart 4), together with the corresponding real exchange rates. There does not appear to be any stable relationship between relative stock prices and real exchange rates. In some periods one can detect strong positive co-movements, whereas in others, there appears to be a negative relationship between the two variables. Can these casual observations be corroborated with more formal statistical methods, and if so, how can the changing pattern of correlations over time be explained?

The remainder of the paper addresses some of these questions. In Section II, formal statistical methods are used to establish a number of empirical regularities that characterize the relationships that exist among national stock price indices and exchange rates. In Section III we present a theoretical model that yields predictions about these same relationships. Section IV asks how well the theoretical model can account for the identified empirical regularities, and Section V identifies some areas for further theoretical and empirical research suggested by our analysis.

II. Empirical Regularities

To motivate the theoretical analysis that follows, a number of empirical regularities involving stock prices, exchange rates, and output prices are examined. Specifically, we shall attempt to determine whether:

(1) Some form of Purchasing Power Parity (PPP) holds when the prices involved are national equity prices rather than goods prices.

(2) Real equity prices are related across countries.

(3) Any country appears to be dominant in the sense that movements in equity prices there "cause" movements in equity prices elsewhere.

CHART 1

NOMINAL STOCK PRICES

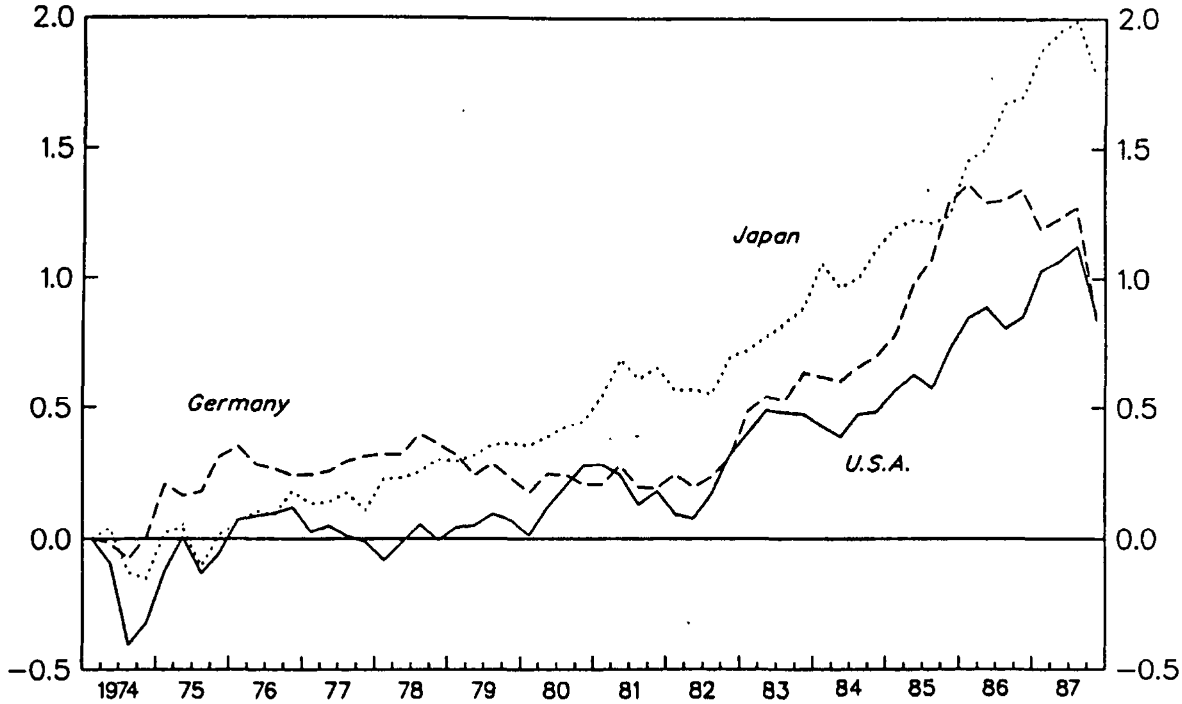
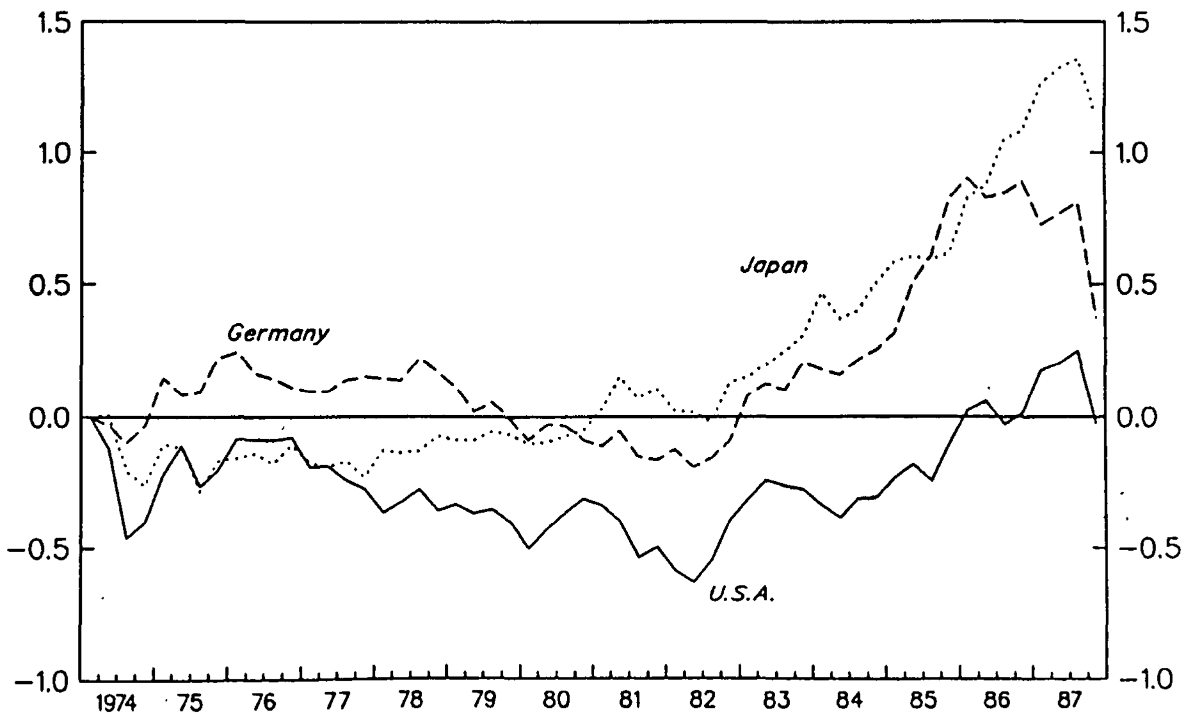


CHART 2

REAL STOCK PRICES



RELATIVE REAL STOCK PRICES AND THE REAL EXCHANGE RATES

CHART 3

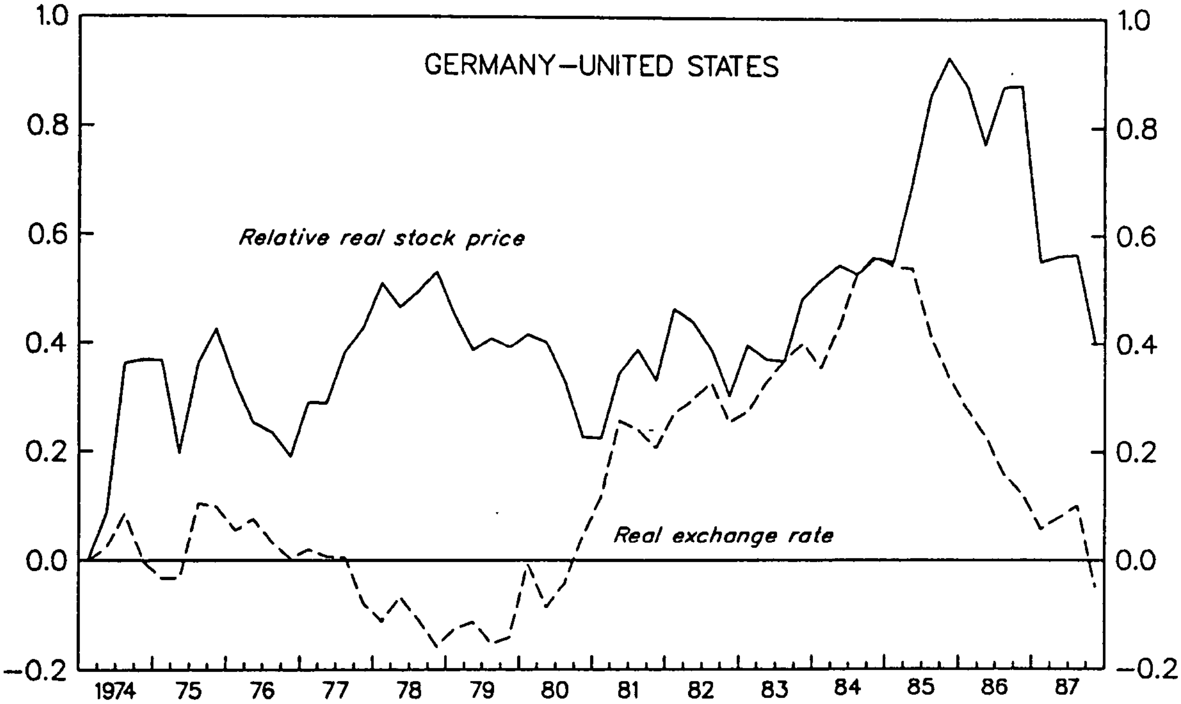
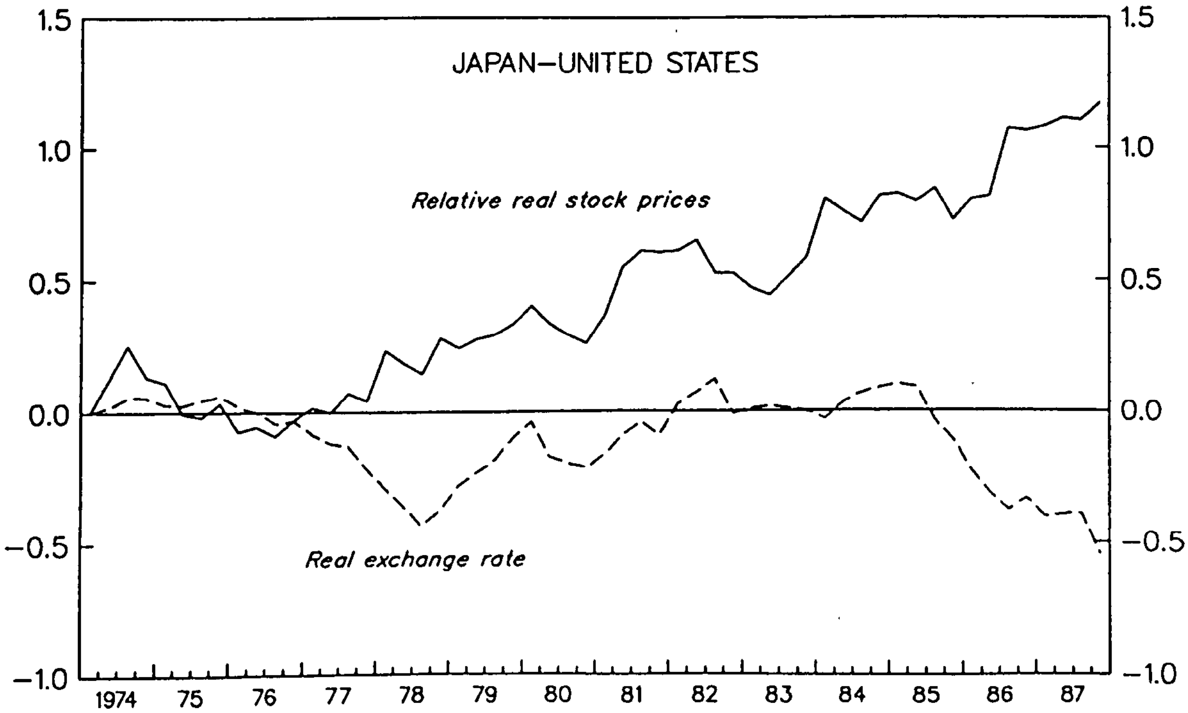


CHART 4



(4) Real equity prices and real exchange rates are correlated, and if so, how?

Before proceeding to these issues, we briefly describe the data series used in the empirical work as well as their time series properties.

1. Data series and their time series properties

Our data sample consists of monthly observations on the following variables for seven major industrial countries: 1/

P^s: an index of the nominal price of equity in the domestic market (expressed in domestic currency);

P: an index of the nominal price of goods in the domestic market (expressed in domestic currency and proxied by the consumer price index);

s^{ij}: the spot exchange rate between currencies i and j (units of i per unit of j).

The following variables were constructed:

$q = P^s/P$: the real price of equity in terms of the domestic price of goods;

$e^{ij} = s^{ij}P^j/P^i$: the real exchange rate between countries i and j.

In order to design appropriate empirical tests it is useful first to determine the time series properties of the data. In particular it is important to know whether the variables are stationary in their levels, or whether it is necessary to first-difference the data in order to remove trends that could introduce spurious correlations. With this in mind, so-called unit-root tests were conducted on each of the variables. 2/ The outcome of these was a clear indication that every data series contains a (stochastic) time trend. First-differencing to make the series stationary will therefore have to be used in subsequent empirical analysis.

2. The relationship between equity prices across countries

a. Does Purchasing Power Parity hold?

Under conditions similar to those that would make PPP hold for prices of goods, one should find that it holds also for nominal equity prices. If equity prices reflect discounted values of future returns to

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1/ Canada, France, the Federal Republic of Germany, Italy, Japan, the United Kingdom, and the United States. Data sources were DRI for all stock price indices and IFS for all other series.

2/ See the Appendix for details.

capital, it ought to be the case that exchange rate changes and nominal stock price changes just offset each other when there are no significant relative price changes of goods between countries, i.e., when the real exchange rate is constant. However, since it is known that the real exchange rate does vary over time, it would be surprising if a corresponding measure using stock prices would not. It might be argued that stock prices reflect not only current conditions but also the expected future conditions, and that they therefore should correspond more closely to the PPP hypothesis on the grounds that movements in real exchange rates tend to be reversed over time. Most empirical evidence seems to suggest, however, that changes in real exchange rates are highly persistent, implying similar persistence in stock prices relative to exchange rates.

In order to investigate the validity of the PPP hypothesis applied to stock prices, we performed two related tests. The first was a test for stationarity of the "real equity exchange rate", defined by

$$e^{sij} = s^{ij}P^{sj}/P^{si} \tag{1}$$

Based on tests described in Section 1 of the Appendix, we could not reject the hypothesis that the real equity exchange rates in our sample follow random walks. This in turn means that there is no tendency for these real rates to converge to a constant, as predicted by the PPP hypothesis.

The second test of the PPP hypothesis was a test of co-integration between P^{si}, P^{sj}, and s^{ij}. This test allows a slightly more general relationship between the three variables than that which says that e^{sij} as defined in equation (1) is a stationary series. Specifically, we investigated the hypothesis that the estimated residual in the regression

$$\ell nP^{si} = \alpha + \beta_1 \ \ell nP^{sj} + \beta_2 \ \ell ns^{ij} + u^i \tag{2}$$

is a stationary time series. 1/ Fifteen pairs of countries defined by the following i,j combinations were used.

j = US i = (Germany, Japan, UK, Canada, France, Italy)

j = Germany i = (Japan, UK, Canada, France, Italy)

j = Japan i = (UK, Canada, France, Italy)

1/ In co-integration tests, equation (2) is interpreted as the long-run relationship between the variables provided that the residual in the equation is stationary, and is referred to as the co-integration regression.

Table 1 reveals that the hypothesis of co-integration could be rejected in all but two cases, (US, Japan) and (Japan, UK), 1/ suggesting that in general there is no stable long-run relationship between nominal stock prices and exchange rates. As we shall see shortly, however, this does not mean that stock price movements in different countries are unrelated. What it does indicate is that relative stock price movements do not simply offset nominal exchange rate changes.

Estimates of the co-integration regressions, equation (2), provided additional clues about the relationship between national equity markets. Whereas the coefficient β_1 is often in the neighborhood of 1, the estimates of β_2 are sometimes positive and sometimes negative, depending on which country pair was examined. 2/ This seems to suggest that nominal stock prices move together independently of nominal exchange rate changes, a hypothesis that will be examined in the next subsection.

b. Nominal stock prices move together <u>independently of nominal exchange rate changes</u>

Since stock prices and exchange rates are not co-integrated and since individually they follow random walks, one might argue that regressions like equation (4) should be estimated on first differences of the variables. Doing so yields the following three conclusions (see Table 2):

(1) There are significant common movements of nominal stock prices across national markets. The coefficient on P^{js} is significantly greater than zero for every country pairing represented in Table 2.

(2) Changes in nominal exchange rates are not systematically related to changes in stock prices. The corresponding coefficient (β_2) is most often not significantly different from zero. Furthermore, while the PPP hypothesis implies that this coefficient should be equal to +1, Table 2 often contains negative point estimates.

(3) The previous conclusions do not seem to be the result of the October 1987 crash since they hold for samples excluding that episode as well. While it is true that the fit of the equation deteriorates when 1987 is excluded from the sample, it is still the case that the coefficient on country j's stock price change is significantly greater than zero at conventional levels. No "improvement" is noticeable regarding the coefficient on the nominal exchange rate.

1/ In the first of these, the point estimate of the coefficient β_2 was −.47 as opposed to the theoretical value of +1 under the null hypothesis of PPP.

2/ Given the non-stationarity of the residual in the regression one must be careful in drawing formal inferences from the estimated coefficients.

Table 1. Tests of Co-Integration Between Nominal Stock Prices and Nominal Exchange Rates

(Co-integration regression: $\ln P^{si}_t = \alpha + \beta_1 \ln P^{sj}_t + \beta_2 \ln S^{i}_{t}j + u_t$)

Country j	Country i	DF	ADF	β_1		β_2	
				(Sample: 1973.6-1988.2)			
United States	Germany	−2.33	−2.48	1.04	(0.03)	0.03	(0.07)
	Japan	−3.78	−3.83	1.42	(0.04)	−0.47	(0.07)
	United Kingdom	−2.66	−2.25	1.60	(0.05)	0.48	(0.09)
	Canada	−2.16	−1.92	0.71	(0.06)	1.54	(0.17)
	France	−2.93	−2.51	1.60	(0.05)	−0.83	(0.06)
	Italy	−2.60	−1.94	2.13	(0.10)	0.11	(0.09)
Germany	Japan	−1.23	−1.72	0.84	(0.07)	−1.41	(0.17)
	United Kingdom	−2.08	−2.40	1.01	(0.08)	1.11	(0.16)
	Canada	−1.58	−1.86	0.67	(0.06)	0.63	(0.10)
	France	−2.64	−2.64	1.02	(0.06)	0.67	(0.11)
	Italy	−1.84	−1.77	1.41	(0.12)	0.55	(0.14)
Japan	United Kingdom	−3.01	−3.48	0.77	(0.05)	0.56	(0.10)
	Canada	−1.87	−1.56	0.58	(0.05)	0.19	(0.10)
	France	−2.43	−2.62	1.08	(0.06)	−0.29	(0.10)
	Italy	−1.71	−1.85	1.56	(0.09)	−0.32	(0.11)

Notes: DF stands for the t statistic for ϕ in the Dickey-Fuller regression $\Delta u_{t-1} = \phi u_{t-1} + \varepsilon_t$. ADF stands for the t statistic of ϕ in the Augmented Dickey-Fuller regression

$$\Delta u_t = \phi u_{t-1} + \sum_{k=1}^{4} b_k \Delta u_{t-k} + \varepsilon_t .$$

Critical values, at the 10 percent level, for DF and ADF are 3.03 and 2.84, respectively. See Engle and Granger (1987), Table II. Numbers in parentheses are standard errors.

Table 2. Estimates of $\Delta\ln P_t^{si} = \alpha_o + \alpha_1 \Delta\ln P_t^{sj} + \alpha_2 \Delta\ln S_t^{ij} + u_t$

Country j	Country i	Sample	α_o		α_1		α_2		D-W	R^2
United States	Germany	88.2	0.0035	(0.94)	0.42	(5.58)	0.11	(1.01)	1.90	0.16
		87.2	0.0058	(1.62)	0.25	(3.26)	0.02	(0.17)	2.02	0.06
	Japan	88.2	0.0094	(2.85)	0.32	(4.89)	−0.14	(−1.49)	2.12	0.13
		87.2	0.0093	(2.89)	0.28	(4.12)	−0.18	(−1.83)	2.13	0.12
	United Kingdom	88.2	0.0059	(1.14)	0.86	(9.07)	−0.10	(−0.71)	1.92	0.33
		87.2	0.0073	(1.47)	0.78	(7.32)	−0.19	(−1.20)	1.87	0.27
	Canada	88.2	0.0026	(0.88)	0.80	(13.24)	−0.88	(−3.86)	2.01	0.57
		87.2	0.0035	(1.13)	0.78	(11.41)	−0.95	(−4.04)	1.98	0.53
	France	88.2	0.0038	(0.82)	0.68	(7.39)	−0.14	(−1.00)	1.83	0.25
		87.2	0.0062	(1.35)	0.62	(6.29)	−0.16	(−1.13)	1.87	0.22
	Italy	88.2	0.0066	(1.16)	0.43	(3.78)	0.10	(0.55)	1.71	0.08
		87.2	0.0090	(1.49)	0.43	(3.33)	0.08	(0.41)	1.69	0.07
Germany	Japan	88.2	0.0099	(3.01)	0.27	(4.33)	−0.16	(−1.47)	2.02	0.11
		87.2	0.0097	(2.94)	0.26	(3.59)	−0.12	(−1.12)	1.98	0.08
	United Kingdom	88.2	0.0083	(1.54)	0.53	(5.18)	−0.23	(−1.21)	1.89	0.15
		87.2	0.0094	(1.68)	0.46	(3.80)	−0.24	(−1.27)	1.84	0.10
	Canada	88.2	0.0040	(0.93)	0.34	(4.19)	−0.07	(−0.54)	2.04	0.10
		87.2	0.0050	(1.92)	0.22	(2.22)	−0.03	(−0.22)	2.03	0.03
	France	88.2	0.0057	(1.19)	0.63	(7.11)	−0.49	(−1.70)	1.87	0.24
		87.2	0.0080	(1.60)	0.52	(4.93)	−0.47	(−1.63)	1.86	0.14
	Italy	88.2	0.0092	(1.54)	0.40	(3.69)	−0.30	(−1.06)	1.76	0.08
		87.2	0.012	(1.81)	0.36	(2.76)	−0.30	(−1.06)	1.72	0.05
Japan	United Kingdom	88.2	0.0049	(0.86)	0.55	(4.49)	−0.18	(−1.09)	1.98	0.11
		87.2	0.0067	(1.17)	0.53	(4.05)	−0.20	(−1.23)	1.95	0.10
	Canada	88.2	0.0025	(0.56)	0.35	(3.66)	−0.17	(−1.39)	2.06	0.08
		87.2	0.0035	(0.78)	0.32	(3.16)	−0.15	(−1.14)	2.07	0.06
	France	88.2	0.0015	(0.29)	0.56	(5.11)	−0.16	(−0.91)	1.88	0.14
		87.2	0.0046	(0.91)	0.49	(.4.25)	−0.12	(−0.73)	1.89	0.10
	Italy	88.2	0.0006	(0.11)	0.59	(.4.76)	0.21	(1.09)	1.76	0.13
		87.2	0.0030	(0.49)	0.58	(4.23)	0.25	(1.29)	1.74	0.12

Notes: All samples start in 1974,1. Numbers in parentheses are t statistics.

c. Real stock prices move together

The same tests were applied to real stock prices, q, and real exchange rates, e. The results confirmed previous conclusions; specifically, (i) the level of real stock prices does not seem to be co-integrated in general across countries, and (ii) there is a strong positive relationship between changes in stock prices in different countries. Detailed results are presented in Tables 3 and 4. While the number of cases in which co-integration cannot be rejected increases somewhat relative to the tests with nominal stock prices and exchange rates, 1/ the majority of the comparisons in Tables 3 and 3a still indicate an absence of such a relationship between real stock prices. As before, the co-integration regressions suggest a one-for-one relationship between the stock price series but no systematic association involving the real exchange rates.

Table 4 shows that the slope coefficient is always highly significant in regressions of the change in real stock prices in one country on the corresponding change in another, thus corroborating the results obtained with nominal stock prices. Including changes in the real exchange rate between the countries in the regression does not add to the explanatory power of the equations. In other words, this variable does not appear to correlate systematically with stock price movements (Table 4a). Splitting the whole sample into three roughly equal parts reveals that the relationship between the stock prices is almost always statistically significant, although some minor instability in the estimated coefficient can be detected. The coefficient on the real exchange rate, on the other hand, continues to be insignificantly different from zero in most cases. Moreover, the point estimates of this coefficient frequently change signs from one sample to another. This suggests that if a relationship exists between stock prices and real exchange rates it is highly time varying. Part 4 of this section will discuss this issue further.

3. Do stock price shocks originate in a particular country?

In order to test whether movements of stock prices in a particular country systematically occur before movements elsewhere, standard causality tests were applied to both real and nominal stock prices in a number of pairs of countries. The results, details of which can be found in Section 2 of the Appendix, support the following two conclusions:

1/ Specifically, the number of cases increased from two pairs of countries to four (three) based on the ADF (DF) statistic and a 10% significance level. When the real exchange rate is included in the co-integration regression (see Table 3a), the number increases to six if the ADF statistic is used, but stays at three according to DF. It is interesting to note that co-integration could be rejected in all but one case when one of the two countries was the United States.

Table 3. Tests of Co-Integration Between Real Stock Prices

(Co-integration regression: $\ln q_t^i = \alpha + \beta \ln q_t^j + u_t$)

Country j	Country i	DF	ADF	β	
		(Sample period: 1973.6-1988.2)			
United States	Germany	−2.37	−2.57	1.01	(0.08)
	Japan	−0.48	−0.22	1.30	(0.14)
	United Kingdom	−1.83	−1.40	1.13	(0.08)
	Canada	−1.70	−1.91	0.53	(0.06)
	France	−2.50	−2.19	1.39	(0.07)
	Italy	−2.13	−1.64	1.80	(0.13)
Germany	Japan	−0.25	−0.69	1.21	(0.07)
	United Kingdom	−3.07	−3.57	0.87	(0.05)
	Canada	−2.24	−2.79	0.26	(0.05)
	France	−3.05	−3.11	0.89	(0.05)
	Italy	−2.53	−2.39	1.00	(0.10)
Japan	United Kingdom	−4.04	−4.83	0.62	(0.02)
	Canada	−2.45	−2.94	0.25	(0.03)
	France	−2.50	−2.64	0.54	(0.04)
	Italy	−2.37	−2.44	0.75	(0.06)

Notes: DF stands for the t statistic for ϕ in the Dickey-Fuller regression $\Delta u_{t-1} = \phi u_{t-1} + \varepsilon_t$. ADF stands for the t statistic of ϕ in the Augmented Dickey-Fuller regression

$$\Delta u_t = \phi u_{t-1} + \sum_{k=1}^{4} b_k \Delta u_{t-k} + \varepsilon_t.$$

Critical values, at the 10 percent level, for DF and ADF are 3.03 and 2.84, respectively. See Engle and Granger (1987), Table II. Numbers in parentheses are standard errors.

Table 3a: Tests of Co-Integration Between Real Stock Prices and Real Exchange Rates

(Co-integration regression: $\ln q_t^i = \alpha + \beta_1 \ln q_t^j + \beta_2 \ln e^{ij} + u_t$)

Country j	Country i	DF	ADF	β_1		β_2	
				(Sample period: 1973.6-1988.2)			
United States	Germany	−2.47	−2.86	1.07	(0.07)	0.41	(0.07)
	Japan	−0.82	−0.88	1.10	(0.13)	−0.80	(0.15)
	United Kingdom	−1.81	−1.41	1.11	(0.8)	0.10	(0.11)
	Canada	−2.28	−2.30	0.61	(0.06)	1.05	(0.13)
	France	−2.50	−2.19	1.39	(0.07)	0.00	(0.08)
	Italy	−2.15	-1.65	1.83	(0.13)	0.14	(0.19)
Germany	Japan	−1.41	−1.67	0.79	(0.07)	−1.04	(0.11)
	United Kingdom	−3.39	−4.00	0.88	(0.05)	−0.28	(0.08)
	Canada	−2.26	−2.79	0.26	(0.05)	0.17	(0.08)
	France	−2.99	−3.03	0.90	(0.06)	0.55	(0.31)
	Italy	−3.15	−2.83	0.79	(0.11)	−1.20	(0.31)
Japan	United Kingdom	−4.33	−5.39	0.52	(0.03)	0.22	(0.08)
	Canada	−2.42	−2.89	0.27	(0.03)	−0.06	(0.07)
	France	−2.40	−2.86	0.90	(0.04)	−1.20	(0.12)
	Italy	−2.25	−3.29	1.02	(0.05)	−1.86	(0.20)

Notes: DF stands for the t statistic for ϕ in the Dickey-Fuller regression $\Delta u_{t-1} = \phi u_{t-1} + \varepsilon_t$. ADF stands for the t statistic of ϕ in the Augmented Dickey-Fuller regression

$$\Delta u_t = \phi u_{t-1} + \sum_{k=1}^{4} b_k \Delta u_{t-k} + \varepsilon_t .$$

Critical values, at the 10 percent level, for DF and ADF are 3.03 and 2.84, respectively. See Engle and Granger (1987), Table II. Numbers in parentheses are standard errors.

Table 4. Estimates of $\Delta lnq_t^i = \alpha_o + \alpha_1 \Delta lnq_t^j + u_t$

Country j	Country i	Sample	α_o		α_1		D-W	R^2
United States	Germany	88.2	0.0026	(0.70)	0.41	(5.63)	1.89	0.16
		87.2	0.0041	(1.17)	0.26	(3.47)	2.01	0.07
	Japan	88.2	0.0076	(2.30)	0.33	(5.10)	2.11	0.13
		87.2	0.0072	(2.18)	0.31	(4.48)	2.11	0.11
	United Kingdom	88.2	0.0019	(0.42)	0.84	(9.12)	1.89	0.33
		87.2	0.0024	(0.48)	0.77	(7.47)	1.83	0.26
	Canada	88.2	-0.0004	(-0.14)	0.85	(13.84)	2.07	0.53
		87.2	-0.0003	(-0.10)	0.83	(12.09)	2.04	0.48
	France	88.2	0.0001	(0.02)	0.68	(7.59)	1.83	0.26
		87.2	0.0018	(0.41)	0.64	(6.66)	1.84	0.22
	Italy	88.2	-0.0014	(-0.25)	0.45	(4.01)	1.71	0.09
		87.2	0.0004	(0.07)	0.45	(3.59)	1.68	0.08
Germany	Japan	88.2	0.0069	(2.03)	0.27	(4.16)	1.96	0.09
		87.2	0.0063	(1.84)	0.26	(3.47)	1.93	0.07
	United Kingdom	88.2	0.0005	(0.09)	0.52	(5.11)	1.83	0.13
		87.2	0.0008	(0.15)	0.44	(3.75)	1.77	0.08
	Canada	88.2	-0.0015	(-0.34)	0.35	(4.22)	2.01	0.10
		87.2	-0.0009	(-0.19)	0.22	(2.27)	2.00	0.03
	France	88.2	-0.0016	(-0.35)	0.62	(7.02)	1.86	0.23
		87.2	-0.0000	(-0.00)	0.51	(4.88)	1.84	0.13
	Italy	88.2	-0.0025	(-0.45)	0.41	(3.84)	1.75	0.08
		87.2	-0.0010	(-0.17)	0.38	(2.95)	1.70	0.05
Japan	United Kingdom	88.2	-0.0021	(-0.39)	0.52	(4.44)	1.97	0.11
		87.2	-0.0009	(-0.17)	0.50	(4.05)	1.93	0.10
	Canada	88.2	-0.0033	(-0.76)	0.36	(3.86)	2.09	0.08
		87.2	-0.0024	(-0.54)	0.34	(3.38)	2.09	0.07
	France	88.2	-0.0042	(-0.84)	0.55	(5.16)	1.90	0.14
		87.2	-0.0014	(-0.29)	0.49	(4.39)	1.90	0.11
	Italy	88.2	-0.0062	(-1.11)	0.62	(5.21)	1.76	0.14
		87.2	-0.0039	(-0.68)	0.62	(4.76)	1.72	0.13

Note: All samples start in 1974, 1. Numbers in parentheses are t statistics.

Table 4a. Estimates of $\Delta \ln q_t^i = \alpha_0 + \alpha_1 \Delta \ln q_t^j + \alpha_2 \Delta \ln e_t^{ij} + u_t$

Country j	Country i	Coefficient	1973,6-1988,2		1973,6-1978,6		1978,7-1983,6		1983,7-1988,2	
United States	Germany	α_1	0.43	(5.91)	0.22	(2.01)	0.34	(3.66)	0.65	(4.06)
		α_2	0.10	(0.96)	0.10	(0.59)	−0.20	(−1.81)	0.27	(1.16)
	Japan	α_1	0.35	(5.32)	0.27	(2.32)	0.22	(2.58)	0.47	(3.51)
		α_2	−0.12	(−1.19)	−0.13	(0.26)	−0.12	(−1.36)	−0.15	(−0.67)
	United Kingdom	α_1	0.84	(9.37)	0.85	(4.28)	0.54	(3.84)	0.94	(9.47)
		α_2	−0.12	(−0.87)	−1.00	(−2.42)	0.02	(0.14)	0.08	(0.56)
	Canada	α_1	0.80	(13.43)	0.69	(7.56)	0.96	(6.60)	0.80	(10.00)
		α_2	−0.65	(−2.95)	−0.53	(−1.38)	−0.90	(−2.23)	−0.21	(−0.61)
	France	α_1	0.68	(7.76)	0.67	(4.25)	0.50	(3.08)	0.79	(5.41)
		α_2	−0.16	(−1.17)	0.09	(0.31)	−0.48	(−2.45)	0.04	(0.18)
	Italy	α_1	0.43	(3.83)	0.39	(2.28)	0.22	(0.89)	0.56	(3.10)
		α_2	0.03	(0.18)	−0.35	(−1.07)	0.22	(0.60)	0.11	(0.37)
Germany	Japan	α_1	0.28	(4.41)	0.38	(2.87)	0.33	(3.29)	0.21	(2.07)
		α_2	−0.02	(−0.19)	0.37	(2.00)	−0.16	(−1.63)	−0.36	(−1.24)
	United Kingdom	α_1	0.53	(5.47)	0.74	(2.66)	0.70	(4.19)	0.41	(3.81)
		α_2	−0.17	(−0.99)	−0.11	(−0.29)	−0.25	(−1.44)	−0.00	(−0.00)
	Canada	α_1	0.36	(4.49)	0.19	(1.23)	0.70	(3.00)	0.31	(3.51)
		α_2	0.02	(0.20)	0.20	(0.96)	−0.02	(−0.09)	−0.10	(−0.52)
	France	α_1	0.64	(7.54)	0.68	(3.66)	0.59	(2.96)	0.63	(6.19)
		α_2	−0.43	(−1.59)	−0.48	(−1.31)	−0.64	(−1.23)	0.56	(0.68)
	Italy	α_1	0.45	(4.25)	0.60	(2.99)	0.26	(0.91)	0.42	(3.11)
		α_2	−0.19	(−0.78)	0.11	(0.44)	−1.27	(−1.94)	−0.30	(−0.29)
Japan	United Kingdom	α_1	0.53	(4.77)	0.53	(2.07)	0.62	(2.83)	0.47	(3.33)
		α_2	−0.15	(−1.03)	−0.22	(−0.51)	−0.15	(−0.89)	−0.11	(−0.45)
	Canada	α_1	0.37	(4.13)	0.19	(1.36)	0.87	(3.25)	0.32	(2.81)
		α_2	−0.15	(−1.18)	0.15	(0.58)	−0.16	(−0.78)	−0.32	(−1.62)
	France	α_1	0.54	(5.42)	0.51	(2.80)	0.45	(1.69)	0.58	(3.79)
		α_2	−0.12	(−0.78)	0.19	(0.60)	−0.38	(−1.66)	−0.01	(0.02)
	Italy	α_1	0.57	(4.91)	0.57	(3.11)	0.33	(0.96)	0.56	(3.06)
		α_2	0.16	(0.86)	−0.13	(−0.46)	0.54	(1.82)	0.15	(0.34)

Note: The numbers in parentheses are t statistics.

(1) There is overwhelming evidence that inter-country stock price relationships are mainly contemporaneous, precluding any firm conclusions as to causality between the variables.

(2) In the (few) cases where lagged responses seem to be present, it is not easy to discern a coherent pattern. For instance, stock price changes in the United States seems to "cause" stock price change in Japan, while the same changes in Japan seems to "cause" those in Germany. However, there is only a contemporaneous relationship between U.S. and German stock price movements.

An implication of these results is that stock prices are either determined by events that are common to all countries or are immediately transmitted between countries. To the extent that the influence of government polices on the domestic economy is transmitted partly by the stock market, a further implication could be that the international transmission of policy shocks is facilitated rapidly by the linkages that exist between national equity markets.

4. Correlation between relative stock prices and real exchange rates

Changes in real exchange rates reflect changes in relative prices of national outputs which in turn, one might conjecture, are related to relative profitability levels and relative returns on capital. This suggests that real exchange rates and relative stock prices could be systematically related across countries. 1/ In order to investigate this possibility, correlation coefficients between changes in relative real stock prices ($\Delta \ell nq^{i} - \Delta \ell nq^{j}$) and changes in real exchange rates ($\Delta \ell ne^{ij}$) were computed for a number of pairs of countries. When the entire 1973-88 sample was used the resulting statistics indicated a virtually complete lack of relationship between the two variables. Inspection of time series plots indicated, however, that significant relationships might exist for sub-periods. To investigate this possibility the correlations were re-computed for moving two-year samples. 2/ Some of the more suggestive results are displayed in Charts 5 - 12.

The main conclusion to be drawn from these charts is that the correlation between real exchange rates and relative stock prices varies considerably over time, so much so that it is sometimes significantly greater and sometimes significantly less than zero. Comparisons of the time patterns of correlations across pairs of countries reveals certain differences and similarities that could form the basis for further empirical tests based on explicit models of the interaction of exchange

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1/ At a popular level it is frequently said that a real depreciation of the domestic currency is "good" for domestic economic activity. According to this argument depreciations ought to be associated with increases in domestic stock prices relative to foreign.

2/ Alternatively, one could run regressions over various sub-periods to test for stability of the relationship.

rates and stock market prices. For example, both Germany and Japan show significant positive correlations with the United States in the early part of the full sample, and negative ones in the 1982-84 period. Also in comparisons with the United States, the correlations are positive for Germany, Italy, and the United Kingdom around 1979-81. One might conjecture that the type of shock responsible for the correlation in one pair of countries is also present in the other pairs.

Additional suggestive patterns can be found. For instance, Charts 9 and 10 show that a number of common elements exist between the United Kingdom and France in comparisons with Germany, and Charts 11 and 12 point to a number of similarities in comparisons of Germany and France with Japan. These similarities could be related to developments and tensions within the EEC in the former case and to differences in macroeconomic and policy developments between Japan and Europe in the latter.

5. Summary: empirical regularities that need to be explained by theoretical models

To sum up, our empirical results suggest that macroeconomic models ought to be capable of explaining the following "empirical regularities".

(1) Nominal stock prices are positively correlated across countries.

(2) Nominal exchange rate changes do not have systematic effects on nominal stock prices. In particular, nominal stock prices do not offset nominal exchange rate changes.

(3) Real stock prices are positively correlated across countries.

(4) The correlation between relative real stock prices and real exchange rates varies over time between significantly positive and significantly negative values. The patterns of variation across pairs of countries contain regularities that are unlikely to appear only by chance.

III. The Model

This section constructs and analyzes a two-country model which is capable of generating patterns of adjustment in real and nominal stock prices, exchange rates and output levels in response to various disturbances occurring in either or both countries. 1/ The first subsection specifies the framework. The second subsection discusses the details of

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1/ The model to be described below can be viewed either as a two-country extension of Gavin (1986), or as a elaboration of existing two-country models such as Bhandari (1982) or Turnovsky (1986), suitably amended to incorporate stock markets in each country.

CORRELATION BETWEEN RELATIVE REAL STOCK PRICES AND REAL EXCHANGE RATE

CHART 5

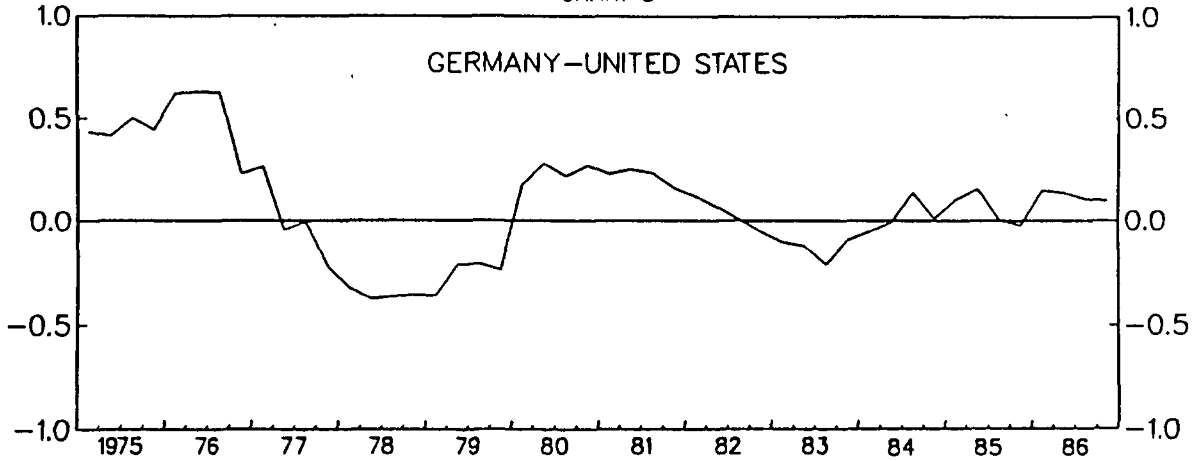


CHART 6

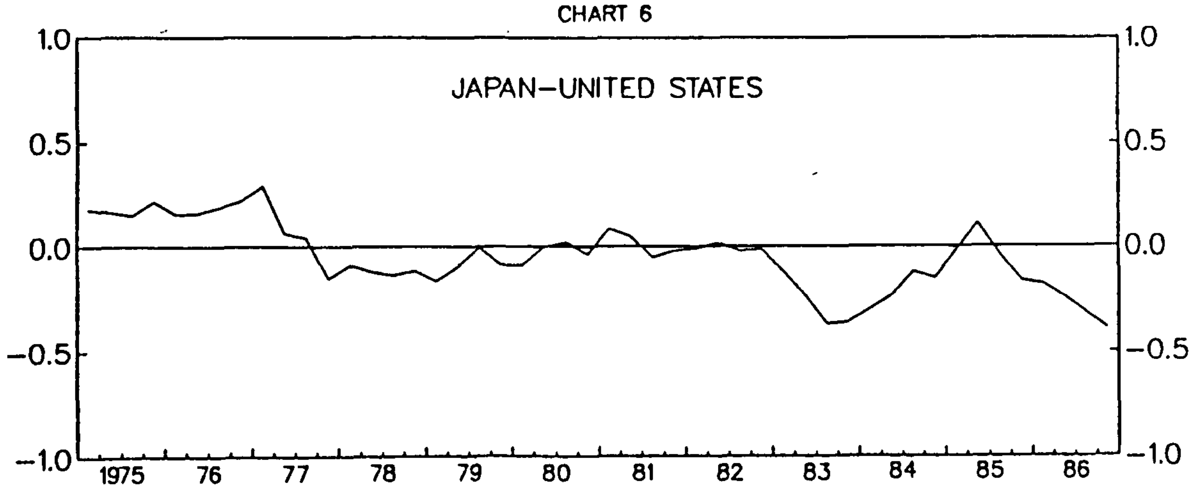
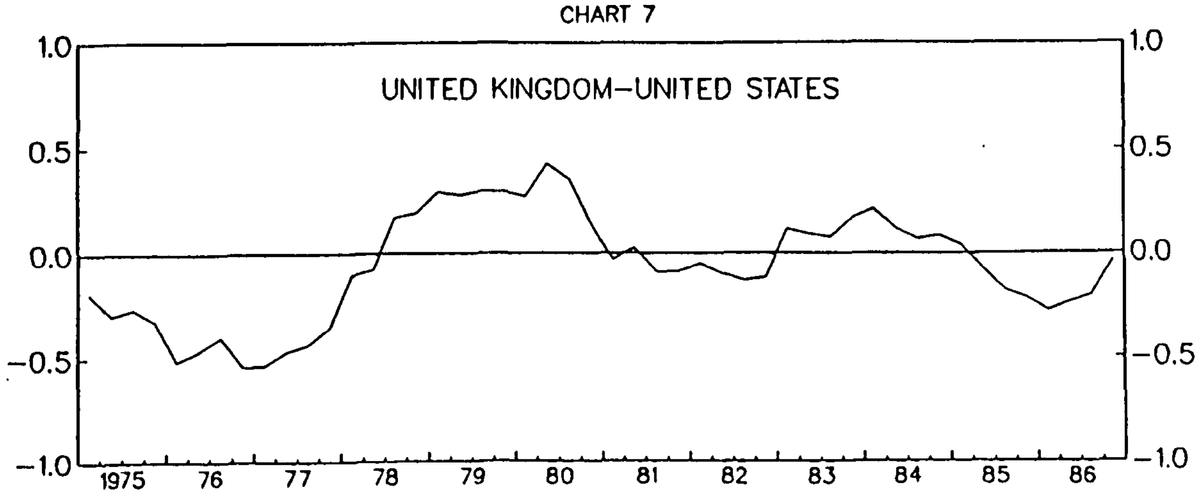


CHART 7



CORRELATION BETWEEN RELATIVE REAL STOCK PRICES
AND REAL EXCHANGE RATES

CHART 8

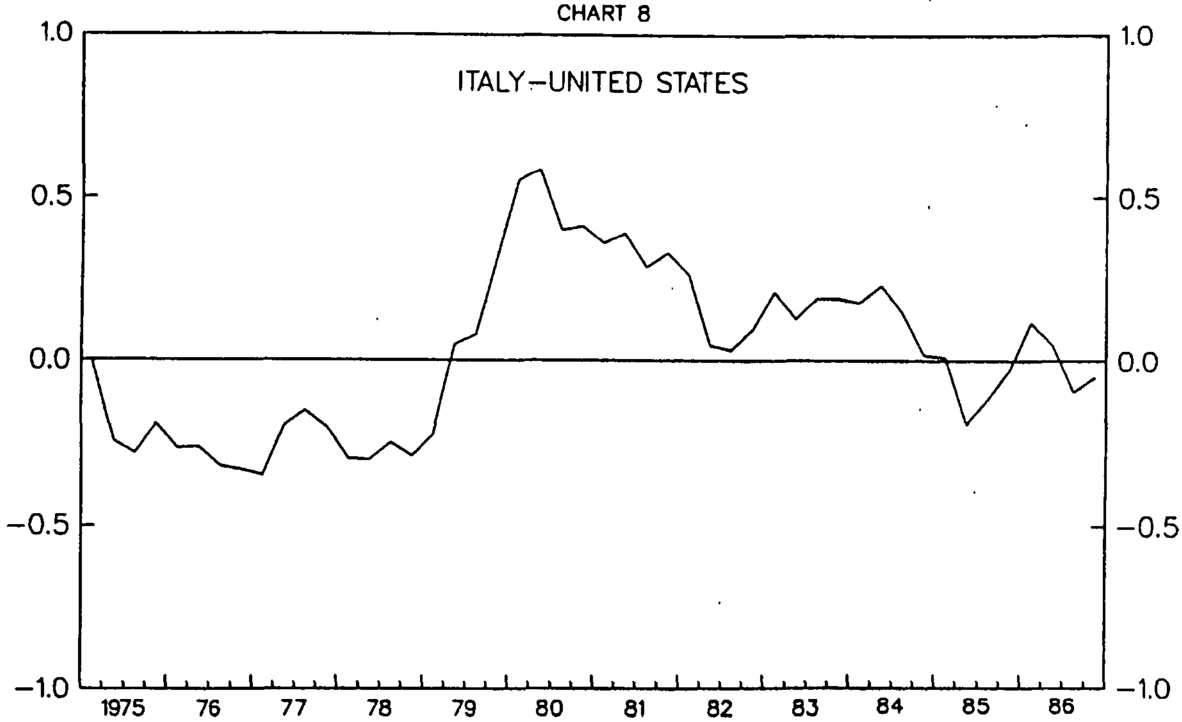
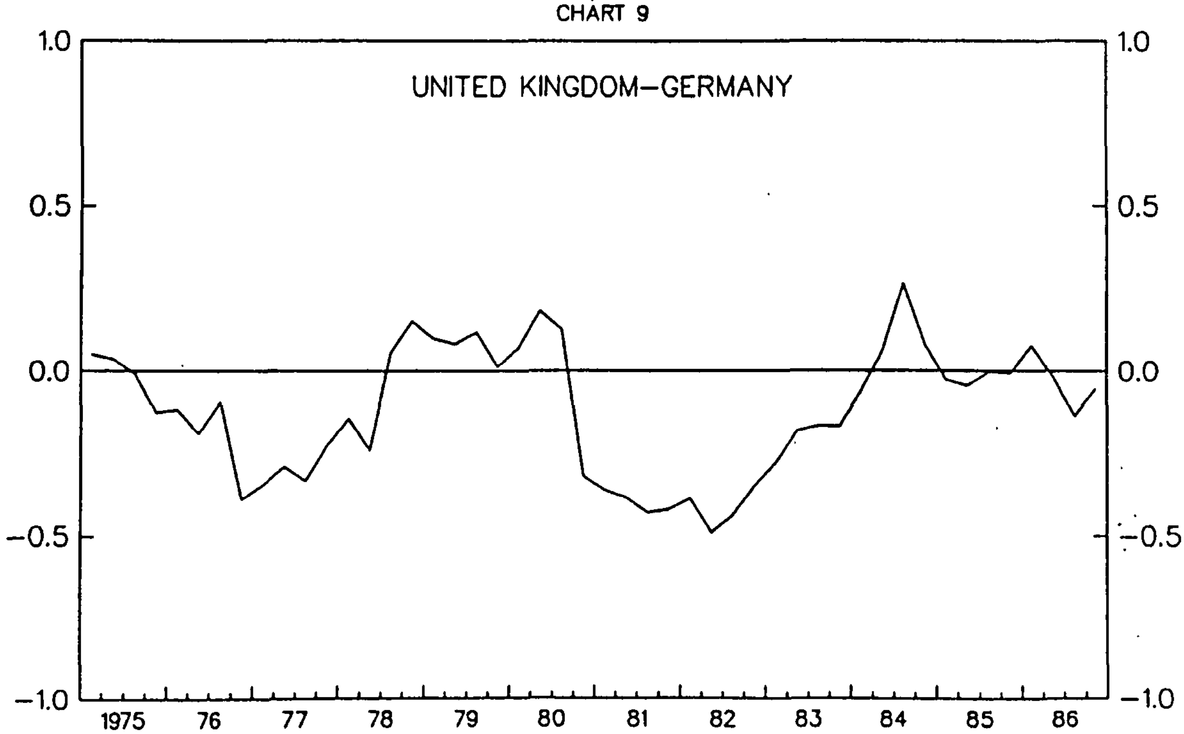


CHART 9



CORRELATION BETWEEN RELATIVE REAL STOCK PRICES AND REAL EXCHANGE RATES

CHART 10

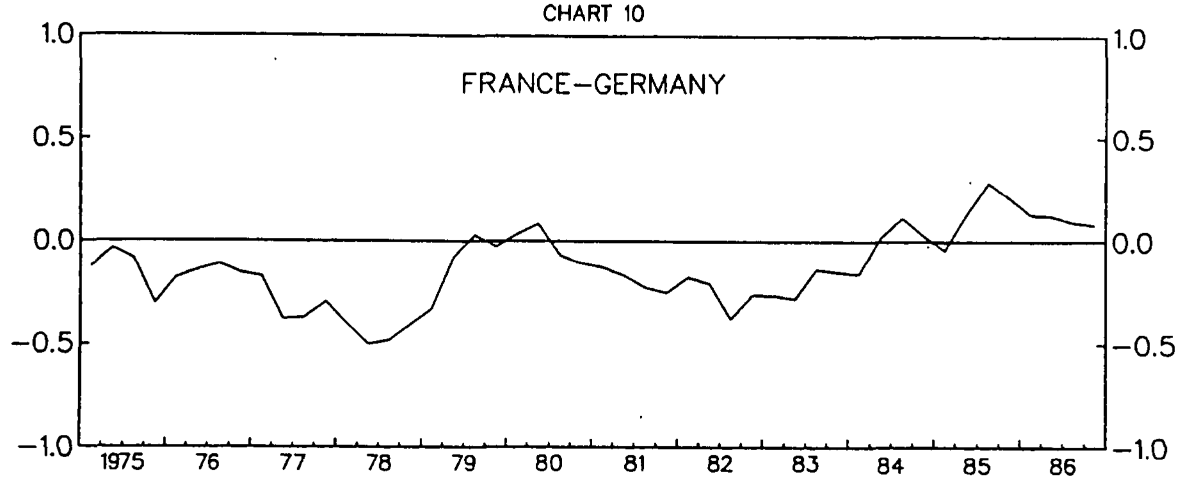


CHART 11

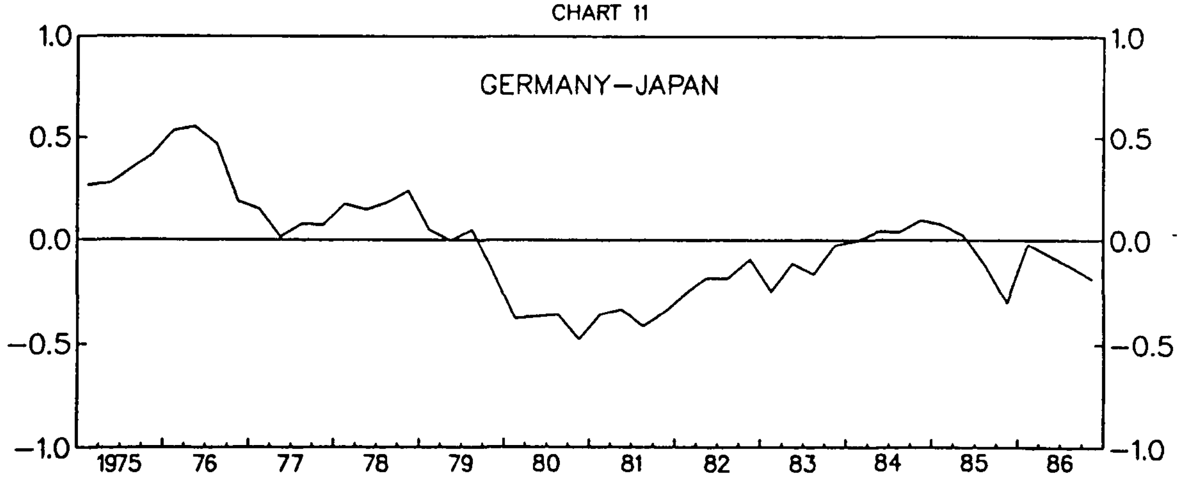
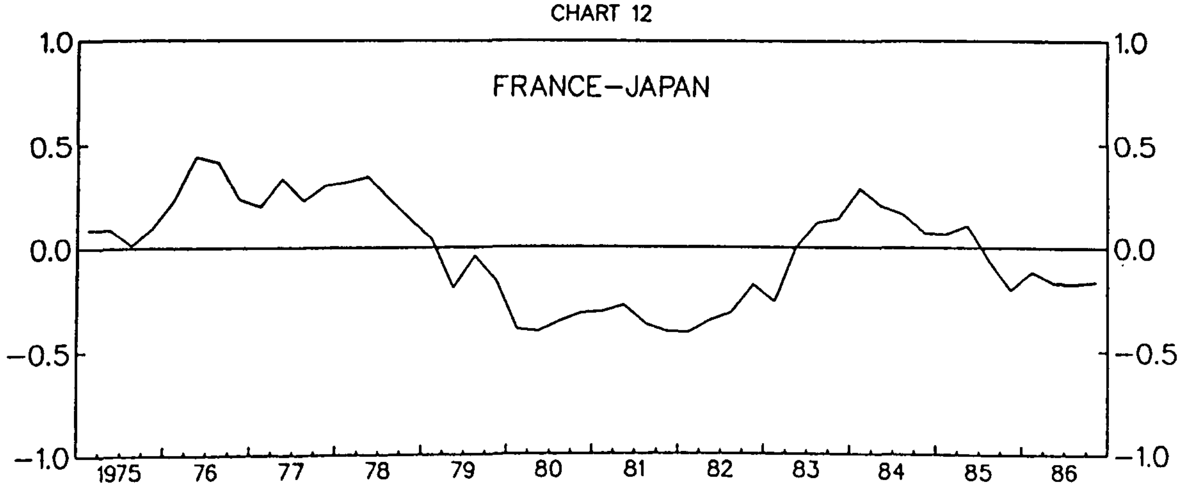


CHART 12



solution to the model, while the final subsection contains a discussion of the worldwide effects of monetary and fiscal disturbances.

1. The analytical framework

The hypothetical world of this model consists of two countries. Each country produces a single final commodity. Both goods are consumed in each country. Each country supplies bonds denominated in its own currency to the world market. These assets are assumed to be perfect substitutes on an uncovered basis so that effectively there is a single internationally traded bond. Domestic residents (in each country) may hold domestically issued money, the international bond or shares of the domestic stock market. For purposes of this model, the alternative assumption of permitting equity shares to be internationally traded leads to entirely insubstantial changes. 1/ There is no currency substitution and all considerations of intermediate products, capital formation, and factor markets are deliberately suppressed. Asset prices including the exchange rate, interest yields, and stock prices adjust instantaneously; however, commodity prices are "sticky" and adjust only over time in response to commodity market disequilibria.

The model contains a description of commodity, money and stock markets in each country, a specification of interest arbitrage, arbitrage relationships between stock market returns, and bond yields, along with a statement of price dynamics in each country. All relevant commodity and asset market parameters in each country are identical, i.e., the analysis envisions a world consisting of two parameter-wise identical, symmetric countries. This assumption relating to identical cross-country parameters permits us to solve an otherwise high-order differential equation system by the use of the averages-differences technique suggested by Aoki (1981).

Aggregate demand in each country is given definitionally by the sum of consumption plus the net trade balance and government expenditure (ignoring for simplicity, the investment component of expenditure). Thus, domestic income (in natural units) is

$$Y = C + X - (SP^*/P).IM + G \qquad (1')$$

1/ The reason for this is that we do not model differences in risk characteristics between stocks issued in different countries. This in turn implies that given certain conditions the arbitrage relationships which must hold between real and financial assets in the model are unaffected by permitting trade in equity shares. One condition under which this is so is that the share of domestic stocks in the domestic portfolio is equal to the share of domestic goods in the domestic general price index.

where C, X, IM and G respectively denote consumption, exports, imports and government expenditure, while S is the nominal exchange rate (number of units of domestic currency per unit foreign currency) and P and P* refer to national price levels. In what follows, upper-case letters denote natural levels of variables while lower-case letters indicate logarithmic values (unless otherwise indicated) and starred values refer to foreign variables. Since the rest of the model is most conveniently specified in logarithmic terms it is necessary to log-linearize equation (1′). A logarithmic linear approximation to equation (1′) is given by

$$\ell nY \approx (C°/Y°)\ln C + \mu_1 \ell nX - \mu_2 \ell nE - \mu_2 \ell nIM + (G°/Y°)\ell nG \qquad (1'')$$

where a '°' indicates an arbitrary initial value and where E (≡ SP*/P) is the real exchange rate and μ_1 and μ_2 are the shares of exports and imports to income respectively, i.e., $\mu_1 \equiv (X°/Y°)$ and $\mu_2 \equiv (E.IM/Y)°$. We next hypothesize the following functional forms for consumption, exports and imports.

$$\ell nC = c = c_1 y + c_2 q$$

$$\ell nX = x = x_1(s+p^*-p) + x_2 y^*$$

$$\ell nIM = im = m_1 y - m_2(s+p^*-p)$$

where q is the real stock price (in terms of domestic output) and all parameters are defined positively. The presence of a stock market effect upon real consumption can be explained by appealing to wealth-type considerations. The reduced form for the logarithm of domestic output can be shown to be given by

$$y = d_1 y^* + d_2 q + d_3(s+p^*-p) + d_4 g \qquad (1)$$

where

$$d_1 = \frac{\mu_1 x_2}{D} \quad ; \quad d_2 = \frac{(C°/Y°).c_2}{D}$$

$$d_3 = \frac{\mu_1(x_1+m_2-1)}{D} \quad ; \quad d_4 = \frac{(G°/Y°)}{D}$$

$$D = [1 - c_1(C°/Y° - \mu_2 m_1)]$$

It is assumed that the Marshall-Lerner condition is satisfied, i.e., $(x_1+m_2-1) > 0$ so that $d_i > 0$ for all i. 1/ The analogous expression for foreign aggregate demand is

$$y^* = d_1 y + d_2 q^* - d_3(s+p^*-p) + d_4 g^* \tag{2}$$

Money market equilibrium in the two countries is described by

$$m - h = \nu_1 y - \nu_2 i \tag{3a}$$

$$m^* - h^* = \nu_1 y^* - \nu_2 i^* \tag{3b}$$

when i and i* are nominal interest yields in the two countries while h and h* are price indices given by 2/

$$h = \delta p + (1-\delta)(s+p^*) \tag{4a}$$

$$h^* = \delta p^* + (1-\delta)(p-s) \tag{4b}$$

$$0 \leq \delta \leq 1$$

It is straightforward to show that $(1-\delta)$, the share of imported goods in home consumption is related to other structural parameters of the model via $(1-\delta) = \mu_2/(C/Y)^\circ$.

Nominal interest yields are linked via the uncovered interest policy condition

$$i = i^* + \dot{s}^e \tag{5}$$

where $\dot{s}^e$ is the expected rate of depreciation of the exchange rate. We posit that expected depreciation is governed by the expectational scheme

$$\dot{s}^e = -\theta(s-\bar{s}) \tag{6}$$

$$\theta > 0$$

1/ In addition, D > 0 is the usual stability condition which is also assumed satisfied.

2/ These price indices are exact if the underlying utility function is Cobb-Douglas in nature.

where θ is the speed of adjustment of expectations towards the long-run value of the exchange rate $\bar{s}$. It will turn out subsequently that this expectational scheme is consistent with perfect foresight for a properly constrained value of θ.

The next set of relations equates the expected real return on a shares, which consists of both capital gains and profits (π, π^*), to the real return on domestic bonds in each country. 1/ Thus,

$$\dot{q}/q + \pi/q = (i-\dot{p}) = r \qquad (7a')$$

$$\dot{q}^*/q^* + \pi^*/q^* = (i^*-\dot{p}^*) = r^* \qquad (7b')$$

Equation (7a')-(7b') can be linearized around the initial steady-state as

$$\dot{q} + \pi = \bar{r}q + \bar{q}r - \bar{q}\,\bar{r} \qquad (7a)$$

$$\dot{q}^* + \pi^* = \bar{r}^*q^* + \bar{q}^*r^* - \bar{q}^*\bar{r}^* \qquad (7b)$$

It may be noted that equation (7') and (7), when solved forward with the appropriate transversality conditions yield an expression for the real stock price as the present value of anticipated future profits when discounted at the real interest rate,

$$q_t = \int_0^{\infty} \pi(\tau)\text{Exp.}^{-\int_t^{\tau} r(t)dt} d\tau$$

Finally, real profits are related procyclically to the deviation of output from its full capacity level,

$$\pi = b_o + b_1(y-\bar{y}) \qquad (8a)$$

$$\pi^* = b_o + b_1(y^*-\bar{y}^*) \qquad (8b)$$

1/ These equations represent arbitrage relationships between bonds and stocks in each economy.

Similar expressions are also used in Gavin (1986). And, as also noted by the latter, when $b_1 = 0$, the "stock" is exactly like an indexed perpetuity so that the model reduces to the standard type without stock market effects. Thus, b_1 measures the extent of departure of the present model from the usual framework wherein stock market effects are excluded. Finally, the parameter b_o measures the "natural" rate of profit in the steady-state.

The final equations of the model specify price dynamics. We assume that price adjustment occurs according to

$$\dot{p} = \gamma(y-\bar{y}) \tag{9a}$$

$$\dot{p}^* = \gamma(y^*-\bar{y}^*) \tag{9b}$$

i.e., prices respond positively to the state of excess demand.

For convenience, we list can the equations comprising the entire model. These are:

$$y = d_1y^* + d_2q + d_3(s+p^*-p) + d_4g \tag{1}$$

$$y^* = d_1y + d_2q^* - d_3(s+p^*-p) + d_4g^* \tag{2}$$

$$m-h = \nu_1 y - \nu_2 i \tag{3a}$$

$$m^*-h^* = \nu_1 y^* - \nu_2 i^* \tag{3b}$$

$$h = \delta p + (1-\delta)(s+p^*) \tag{4a}$$

$$h^* = \delta p^* + (1-\delta)(p-s) \tag{4b}$$

$$i = i^* + \dot{s}^e \tag{5}$$

$$\dot{s}^e = -\theta(s-\bar{s}) \tag{6}$$

$$\dot{q}+\pi = \bar{r}q+\bar{q}r-\bar{q}\ \bar{r} \tag{7a}$$

$$\dot{q}^*+\pi^* = \bar{r}^*q^*+\bar{q}^*r^*-\bar{q}^*\bar{r}^* \tag{7b}$$

$$r = (i-\dot{p}) \tag{7a'}$$

$$r^* = (i^*-\dot{p}^*) \tag{7b'}$$

$$\pi = b_o+b_1(y-\bar{y}) \tag{8a}$$

$$\pi^* = b_o+b_1(y^*-\bar{y}^*) \tag{8b}$$

$$\dot{p} = \gamma(y-\bar{y}) \tag{9a}$$

$$\dot{p}^* = \gamma(y^*-\bar{y}^*) \tag{9b}$$

2. Solution of the model

This subsection discusses the solution to the model described above. Inspection of the model immediately reveals that the model as described involves fourth-order dynamics with equations involving $\dot{p}$, $\dot{p}^*$, $\dot{q}$ and $\dot{q}^*$. 1/ Because such a system is analytically intractable we proceed instead to utilize the method of averages and differences proposed by Aoki (1981). Essentially, this technique permits us to decouple the dynamic system into two sub-systems, one involving averages of variables and the other involving differences (across countries) in the same variables. Each of these two sub-systems is second-order in nature and is therefore, analytically tractable. 2/ It is convenient to begin with the steady-state solution to the model. Following that, we discuss the dynamics of the two sub-systems and then the saddle point paths which yield us the impact effects for various disturbances.

a. The steady state

In the steady state of the model $\dot{s} = \dot{s}^e = \dot{p} = \dot{p}^* = \dot{q} = \dot{q}^* = 0$. 3/ From the interest parity condition equation (5), along with the definition real interest rates, it follows that nominal and real interest rates are equalized across countries in the steady state,

$$\bar{i} = \bar{i}^* , \; \bar{r} = \bar{r}^* \text{ and } \bar{i} = \bar{r} , \; \bar{i}^* = \bar{r}^* \tag{10}$$

Next, steady-state profits are (from equation (8))

$$\bar{\pi} = \bar{\pi}^* = b_o \tag{11}$$

and equation (7) yields

1/ An additional dynamic equation involving $\dot{s}$ would ordinarily have been involved had we imposed perfect foresight directly instead of utilizing the expectational scheme described in (6).

2/ The averages-differences technique can also be utilized if parameters are not country-wise identical; however, additional approximations are involved in this case. See Aoki (1981) for details.

3/ It is straightforward however, to incorporate ongoing inflation in the steady state.

$$\bar{q} = \bar{q}^* \tag{12}$$

i.e., steady-state real stock prices are also equalized. Explicit solutions for the exchange rate, price levels, and stock prices may now be obtained by using the goods market and money market conditions. These are

$$\bar{q} = \bar{q}^* = K_i - \frac{d_4}{2d_2}(g + g^*) \tag{13}$$

$$\bar{i} = \bar{i}^* = \bar{r} = \bar{r}^* = \frac{b_o}{\bar{q}} \tag{14}$$

$$(\bar{s} + \bar{p}^* - \bar{p}) = K_i - \frac{d_4}{2d_3}(g - g^*) \tag{15}$$

$$\bar{p} = m + \frac{(1-\delta)d_4}{2d_3}(g - g^*) + \frac{\nu_2 b_o}{K_i-(d_4/2d_2)(g+g^*)} + K_i \tag{16}$$

$$\bar{p}^* = m^* - \frac{(1-\delta)d_4}{2d_3}(g - g^*) + \frac{\nu_2 b_o}{(K_i-(d_4/2d_2)(g+g^*)} + K_i \tag{17}$$

$$\bar{s} = K_i + (m - m^*) + \left[\frac{d_4(1-2\delta)}{2d_3}\right]\left[g - g^*\right] \tag{18}$$

where the K_i's refer to constants that are unnecessary for what follows. Equations (13) - (18) indicate that a monetary expansion in one country, say the domestic country, increases that country's price level and nominal exchange rate equiproportionately. There is no transmission to the foreign country's price level in the steady-state. At the same time real stock prices and the real exchange rate remain unaffected. By contrast, an increase in domestic government expenditure reduces real stock prices and thereby increases nominal and real interest yields. It is also seen that while domestic prices increase following domestic fiscal expansion, the effect upon foreign prices is uncertain, i.e., either positive or negative transmission could occur. Finally, while the real exchange rate appreciates in standard fashion, the effect upon the nominal exchange rate is contingent upon the proportions of domestic versus foreign goods in the price index. Specifically, the usual result of nominal appreciation occurs only if the share of domestic goods in the domestic price index is less than one half.

b. Dynamics and impact effects

The solution to the dynamics and impact effect in the model is obtained by decomposing the model into two sub-systems involving averages and differences respectively. Defining average and difference variables respectively as

$$B^a \equiv (B* + B*)/2 \;;$$

$$B^d \equiv (B* - B*)$$

where B and B* are any domestic and foreign variable, the model can be written in average form as

$$m^a - h^a = \nu_1 y^a - \nu_2 i^a \tag{19a}$$

$$\dot{p}^a = \gamma(y^a - \bar{y}^a) \tag{19b}$$

$$\dot{q}^a + \pi^a = \bar{r} q^a + \bar{q} r^a - \bar{q}\,\bar{r} \tag{19c}$$

$$\pi^a = b_o + b_1 (y^a - \bar{y}^a) \tag{19d}$$

This subsystem involves second-order dynamics which can be expressed as

$$\begin{bmatrix} \dot{p}^a \\ \\ \dot{q}^a \end{bmatrix} = \begin{bmatrix} 0 & \gamma d_2/(1-d_1) \\ \\ \bar{q}/\nu_2 & [\bar{r} + \frac{d_2}{1-d_1}(\frac{\bar{q}\nu_1}{\nu_2} - \bar{q}\gamma - b_1)] \end{bmatrix} \begin{bmatrix} (p^a - \bar{p}^a) \\ \\ (q^a - \bar{q}^a) \end{bmatrix} \tag{20}$$

The roots of equation (20) are given by

$$\zeta = \left[\kappa \pm \sqrt{\kappa^2 + (4\bar{q}\gamma d_2/\nu_2(1-d_1))} \right] / 2$$

where

$$\kappa = \left[\bar{r} + \frac{d_2}{1-d_1}\left(\frac{\bar{q}\nu_1}{\nu_2} - \bar{q}\gamma - b_1\right) \right]$$

It is clear that a saddle point exists irrespective of whether $\kappa \gtrless 0$, i.e., one root is positive and the other negative.

The difference model may be written as

$$(1-d_1)(y^d-\bar{y}^d) = d_2(q^d-\bar{q}^d) + 2d_3(s-\bar{s}) - 2d_3(p^d-\bar{p}^d) \tag{21a}$$

$$[2(1-\delta) + \nu_2\theta](s-\bar{s}) = -(2\delta-1)(p^d-\bar{p}^d) - \nu_1(y^d-\bar{y}^d) \tag{21b}$$

$$m^d - (h^d-\bar{h}^d) = \nu_1(y^d-\bar{y}^d) + \nu_2\theta(s-\bar{s}) \tag{21c}$$

$$(h^d-\bar{h}^d) = (2\delta-1)(p^d-\bar{p}^d) + 2(1-\delta)(s-\bar{s}) \tag{21d}$$

$$\dot{p}^d = \gamma(y^d-\bar{y}^d) \tag{21e}$$

$$\dot{q}^d + \pi^d = \bar{r}(q^d-\bar{q}^d) + \bar{q}r^d \tag{21f}$$

$$\pi^d = b_1(y^d-\bar{y}^d) \tag{21g}$$

After considerable re-arrangement the dynamics of this sub-system may be shown to be given by

$$\begin{bmatrix} \dot{p}^d \\ \dot{q}^d \end{bmatrix} = \begin{bmatrix} -a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} (p^d-\bar{p}^d) \\ (q^d-\bar{q}^d) \end{bmatrix} \tag{22}$$

where

$$a_{11} = \frac{2d_3\gamma(1+\nu_2\theta)}{\{(1-d_1)[2(1-\delta)+\nu_2\theta]+2d_3\nu_1\}} > 0$$

$$a_{12} = \frac{\gamma d_2[2(1-\delta)+\nu_2\theta]}{\{(1-d_1)[2(1-\delta)+\nu_2\theta]+2d_3\nu_1\}} > 0$$

$$a_{21} = \left[\frac{a_{11}(b_1+\bar{q}(2\delta-1)\gamma)}{\gamma} - \frac{\bar{q}(2\delta-1)\theta(\nu_1 a_{11} - \gamma(2\delta-1))}{\gamma(2(1-\delta)+\nu_2\theta)} \right]$$

$$a_{22} = \left[\bar{r} + \frac{\bar{q}(2\delta-1)\theta\nu_1 a_{12}}{\gamma(2(1-\delta)+\nu_2\theta)} - \frac{a_{12}(b_1+\bar{q}(2\delta-1)\gamma)}{\gamma} \right]$$

Saddle point stability requires that $-[a_{11}\, a_{22} + a_{12}\, a_{21}] < 0$. As is evident this condition is not met without additional restrictions. Sufficient conditions for saddle point stability are $a_{21}, a_{22} > 0$. It may be readily verified that with a value of $\bar{r}$ large enough, both a_{22} and a_{21} are positive. Assuming that saddle point stability does exist, the stable solutions to equations (20) and (22) are given by

$$(p^a - \bar{p}^a) = (p_o{}^a - \bar{p}^a)\text{Exp.}^{\zeta t}$$

$$(p^d - \bar{p}^d) = (p^d{}_o - \bar{p}^d)\text{Exp.}^{\lambda t}$$

where ζ, $\lambda < 0$ are the stable roots. The saddle point paths corresponding to these sub-systems are

$$(q_o^a - \bar{q}^a) = \frac{\zeta(1-d_1)}{\gamma d_2}\,(p_o^a - \bar{p}^a) \qquad (23)$$

$$(q_o^d - \bar{q}^d) = \left(\frac{\lambda + a_{11}}{a_{12}}\right)\left(p_o^d - \bar{p}^d\right) \text{ 1/} \qquad (24)$$

along with

$$(s_o - \bar{s}) = -\left[\frac{\gamma(2\delta-1)+\nu_1\lambda}{\gamma(2(1-\delta)+\nu_2\theta)}\right]\left[p_o^d - \bar{p}^d\right] \qquad (25)$$

It is straightforward to show that the perfect foresight value of the expectational parameter θ is $\theta^* = -\lambda$. Finally, the impact effects upon output (average and difference forms) are given by

1/ Recall that $\bar{q} = \bar{q}^* = \bar{q}^a$ and $\bar{q}^d = 0$.

$$(1-d_1)(y_o^a - \bar{y}^a) = d_2(q_o^a - \bar{q}^a) \tag{26}$$

$$(y_o^d - \bar{y}^d) = \left(\frac{d_2}{1-d_1}\right)(q_o^d - \bar{q}^d) + \left(\frac{2d_3}{1-d_1}\right)(s_o - \bar{s}) - \left(\frac{2d_3}{1-d_1}\right)(p_o^d - \bar{p}^d) \tag{27}$$

The long-run effects of any disturbance are obtained from equations (10)-(18). The impact effects upon average and difference variables is thus given from equations (23)-(27), keeping in mind that p_o^a and p_o^d are not "jump" variables and evolve only over time. Once the impact effects upon average and difference variables is known, the effects upon original variables are easily obtained as follows:

$$B_o = (B_o^d + 2B_o^a)/2 \tag{28a}$$

$$B_o^* = (2B_o^a - B_o^d)/2 \tag{28b}$$

where $B_o = \{p_o, p_o^* \; q_o, q_o^*, y_o, y_o^*\}$.

3. Effects of nominal and real disturbances

a. Monetary expansion

Consider first the effects of a domestic monetary expansion as represented by $dm > 0$. As indicated previously, such a disturbance produces no steady-state effects upon $\bar{q}$ (real stock prices in either country), $\bar{p}^*$ (foreign price level), $\bar{e}$ (real exchange rate) and either interest rate. It leads however, to equiproportionate increases in the domestic price level ($d\bar{p}/dm = 1$) and the nominal exchange rate ($d\bar{s}/dm = 1$). The impact effect upon the nominal (and real) exchange rate of a domestic monetary expansion is given by equation (25) and is

$$\frac{ds_o}{dm} = (1 + Z) \tag{29}$$

where $Z = \left[\frac{\gamma(2\delta-1)+\nu_1\lambda}{\gamma\{2(1-\delta)+\nu_2\theta\}} \right]$

It is clear from equation (29) that if $Z > 0$, we have exchange rate "overshooting" and conversely for $Z < 0$. It will turn out that there will always be nominal exchange rate overshooting for either monetary or real disturbances but not both. This will become apparent shortly. The effects upon real stock prices in the two countries following domestic monetary expansion are

$$\frac{dq_o}{dm} = \frac{-\dfrac{(\lambda+a_{11})}{a_{12}} - \dfrac{2\zeta(1-d_1)}{2\gamma d_2}}{2} \gtrless 0 \tag{30a}$$

$$\frac{dq_o^*}{dm} = \frac{-\dfrac{2\zeta(1-d_1)}{2\gamma d_2} + \dfrac{(\lambda+a_{11})}{a_{12}}}{2} \gtrless 0 \tag{30b}$$

i.e., effects upon stock prices are a priori unclear. 1/ Exactly symmetric effects of course, occur for an increase in foreign money supply. Finally, output effects are obtained from equations (26)-(27). Additional insight into the qualitative and quantitative effects involved will be obtained from the numerical simulations considered below.

The transitional effects of the disturbance upon these variables can be determined by reference to the steady-state and impact effect and by virtue of the fact that adjustment along the stable path must occur in accordance with a first-order exponential path. 2/ Specifically, foreign prices remain unaffected throughout the adjustment process (since no turning points are possible with first-order dynamics). Domestic prices are increasing during adjustment while the nature of the exchange rate path depends upon whether or not there is initial overadjustment; if there is initial overshooting the nominal exchange rate (and a fortiori the real exchange rate) declines during the adjustment phase. The transitional effects upon other variables, such as domestic and foreign real stock prices and output levels, cannot be unambiguously obtained in view of the fact that the impact effects upon these variables is ambiguous without further restrictions. In what follows we report the results of numerical sensitivity analysis with respect to several parameters of interest.

Meanwhile, the properties thus far noted may be reconciled with the model as follows. An increase in money supply in the domestic country causes domestic nominal bond yields to decline, which ceteris paribus

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1/ It may be shown that the average level of stock prices increases following an increase in domestic money, while the effect upon the difference level is unclear, i.e.,

$$(dq_o^a/dm) = -\frac{\zeta(1-d_1)}{2\gamma d_2} > 0 \ ; \ (dq_o^d/dm) = -\frac{(\lambda+a_{11})}{a_{12}} \gtrless 0$$

2/ Along the perfect foresight path, the stable root is given by $\lambda < 0$.

requires expected exchange appreciation in order to maintain uncovered yields in line (see equation (5)). Such an expected appreciation can only result if the current spot exchange rate has initially overshot its long-run equilibrium value (see Bhandari (1982)). In the present context however, there are countervailing considerations at work that serve to dampen the extent of the initial exchange rate adjustment. First, the use of the price index deflator in the domestic money market condition (equation (3a)) moderates the degree of excess supply created by the monetary expansion (via the increase in the nominal exchange rate which increases the price index h; see equation (4a)). The moderation in the degree of excess money supply calls forth a smaller decline in nominal interest rates and hence a correspondingly diminished extent of expected appreciation (and hence, present exchange depreciation). Second, current nominal exchange depreciation also implies current real depreciation at home, which stimulates domestic output (while depressing foreign output). The increase in domestic output again diminishes the degree of excess money supply engendered by the nominal monetary expansion via equation (3a) and therefore, also reduces the extent of current nominal depreciation as indicated previously. Finally, to the extent that foreign nominal interest yields are lowered in response to the domestic monetary increase, equation (5) indicates that the requisite degree of expected appreciation (and hence current nominal depreciation) is reduced. Thus, while domestic monetary expansion causes current nominal depreciation, the extent of the latter may or may not exceed its long-run effect. 1/

The effect of the domestic monetary expansion upon real stock prices is less clear but may be expected to be positive in the normal case when domestic output increases. Note first that the domestic real interest rate declines unambiguously in response to the disturbance. 2/ Since profits increase in the normal case (in view of the increase in domestic output; see equation (8a)) and the domestic real interest yield declines, it is clear from the arbitrage equation (7a′) that domestic real stock prices increase, thus calling forth a capital loss sufficiently large to maintain parity between competing asset yields, in accordance with equation (7a′). 3/

The effects of the domestic monetary expansion upon foreign variables is also a priori ambiguous. Specifically, two conflicting effects upon foreign output are manifest even in the normal case in which domestic output increases. First, real depreciation of the domestic exchange rate exerts a depressive effect upon foreign output (see equation (2)). At the same time however, the increase in domestic output tends to stimulate

1/ In fact, numerical simulations indicate that for a wide variety of parameter magnitudes, nominal exchange rate undershooting rather than overshooting occurs.

2/ This is because of the decline in the nominal interest rate coupled with an increase in rate of expected (and actual) inflation ($\dot{p}$).

3/ Notice also that $\dot{q} < 0$, since q must return to its predisturbance level along a first-order path.

foreign output directly so that the net effect upon the latter is not clear. As a result, no unambiguous statement in respect of foreign profits and foreign real stock prices can be made without assigning specific parameter magnitudes.

b. Fiscal expansion

Next consider the effects of domestic fiscal expansion, i.e., $dg > 0$. The steady-state effects of such a disturbance are given by equations (13)-(18) as previously. The effect upon the initial exchange rate (in relation to the long-run exchange rate is given by (using the saddle point path equation (25)),

$$\left(\frac{ds_o}{dg} - \frac{d\bar{s}}{dg} \right) = \frac{Ƶ(1-\delta)d_4}{d_3} \tag{31}$$

It is immediately clear upon inspection of equation (31) that the nominal exchange rate will overshoot (i.e., appreciate to a greater extent than the long-run rate) if $Ƶ < 0$. 1/ Interestingly, it will be recalled that in precisely these circumstances exchange rate undershooting must occur in response to monetary expansion (see equation (29)). It has been established therefore, that nominal exchange rate overshooting must occur for either monetary or real disturbances but not both. In what follows, we will argue that the much more likely pattern is overshooting for real disturbances and undershooting for nominal disturbances and our numerical simulations do, in fact, corroborate our view in this regard.

A domestic fiscal expansion leads on impact to increased nominal (and real) interest yields. Uncovered interest parity therefore requires expected nominal depreciation, which in turn necessitates an immediate nominal appreciation in excess of steady-state appreciation. Furthermore, domestic output increases in the normal case as a result of the disturbance which causes domestic bond yields to increase further. 2/ In contrast to monetary disturbances therefore, the income effects attendant upon such a disturbance serve to exacerbate the degree of initial overadjustment in nominal exchange rates. As earlier, the effects of such a disturbance upon domestic real stock prices is obtained via the bond-stock arbitrage in equation (7a'). Specifically, to the extent that the real bond yield (r) increases, real stock prices at home must decline and the outcome is in fact borne out by our numerical analysis. The effects

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1/ Notice also that with $\delta = 1$ (i.e., if the national price level were used in place of the price index), there are no dynamic effects upon the exchange rate following fiscal expansion, i.e., $(ds_o/dg)=(d\bar{s}/dg)$.

2/ Two conflicting effects upon domestic output are observed. First, domestic fiscal expansion directly stimulates domestic income while the resulting real appreciation exerts a depressive effect; see equation (1).

upon foreign income and foreign real stock prices are a priori indeterminate in view of the conflicting effects involved. 1/

4. Numerical sensitivity analysis

In order to gain further insights into the properties of the model described above and in view of some of the theoretical ambiguities encountered, we also performed numerical sensitivity analysis. This subsection reports briefly on the principal results of interest for a few selected sensitivity exercises. The results are presented in Table 5.

Case 1 sets out a baseline or benchmark case with the following parameter configuration:

$\nu_1 = 1$, $\nu_2 = 5$, $\mu_1 = \mu_2 = 0.20$, $(C°/Y°) = 0.90$, $(G°/Y°) = 0.25$,

$x_1 = m_2 = 0.75$, $x_2 = m_1 = 0.50$, $\delta = 0.7778$, $\gamma = \theta = 0.1667$, $c_1 = 0.70$,

$c_2 = 0.024$, $b_o = 0.25$, $b_1 = 1$, $\bar{r} = 0.04$, $\bar{q} = 6.25$

These magnitudes are chosen in view of the following considerations. First, the income elasticity of money demand (ν_1) is fixed at unity. a_2 is the interest rate semi-elasticity of money demand and is given by (interest rate elasticity)/(nominal interest yield). Assuming an interest rate elasticity of 0.25 and a semi-annual nominal interest yield of 5% (the horizon of the model is assumed to extend over semi-annual periods), results in ν_2 being 5. The initial shares of exports or imports to income are each fixed at $\mu_1 = \mu_2 = 0.20$. The average propensity to consume $(C°/Y°)$ is 0.90, while the initial share of government expenditure to total expenditure $(G°/Y°)$ is 0.25. 2/ Next, the elasticities of both exports and imports with respect to the real exchange rate are assumed to be $x_1 = m_2 = 0.75$, while the elasticities of exports with respect to foreign income (x_2) and of imports with respect to income (m_1) are 0.50 each. As indicated in the text, the parameter δ (relating to the consumer price index) is given as $(1-\delta) = \mu_2/(C°/Y°)$. We assume that full adjustment requires 6 periods (i.e., 3 years). This implies that $\gamma=\theta=0.1667$. Next, the elasticity of consumption with respect to income (c_1) is 0.70 while the semi-elasticity of consumption with respect to real stock prices (c_2) is assumed to be 0.024. 3/ Next, b_o (share of profits to income,

1/ There are three channels of effect upon y^*; specifically, the increase in the domestic income and real appreciation both of which serve to increase y^* (see equation (2)); however, a decline in foreign stock prices works in the opposite direction.

2/ These magnitudes are roughly similar to those in Gavin (1986) and several other studies and are in broad conformity with empirical data for the G-7 countries.

3/ Note that c_2 = (elasticity of consumption)/($\bar{q}$), while the elasticity of consumption with respect to q is given by the product of the elasticity of consumption with respect to wealth and the elasticity of wealth with respect to q. This product is assumed to be .15. Given $\bar{q} = 6.25$, the value of $c_2 = .024$ follows.

when measured near the steady-state) is 0.25, while b_1 can be shown to be given by b_o times the elasticity of profits with respect to income. Assuming the latter elasticity to be 4 (as in Gavin (1986)) results in $b_1 = 1$. The semi-annual real interest yield ($\bar{r}$) is 0.04 from which it follows that $\bar{q} = (b_o/\bar{r}) = 6.25$.

Other cases (case 2-6) involve changes in certain parameters of interest such as ν_2, c_2 and $\bar{r}$. The parameter c_2 measures the importance of stock market effects upon demand and is particularly relevant. Case 7 is the "indexed bond" case wherein $b_1 = 0$. Finally, cases 8 and 9 are based upon the parameters magnitudes used by Gavin (1986) subject to certain minor modifications.

The following observations can be made upon inspection of Table 5. First, there is no case in which the saddle point properties of the model fail to hold so that unique solutions are found in every case. Second, monetary expansion occurring in the domestic country leads in every case to nominal exchange rate undershooting, increased domestic output and an increase in domestic stock prices in every case. However, the disturbance is negatively transmitted to foreign output except in three cases (cases 3, 4 and 8) and is positively transmitted to foreign stock prices (although in damped fashion) in every case. Finally, domestic real expenditure expansion always causes exchange rate overshooting, an increase in domestic output and a decline in foreign stock prices in every instance. In five cases (cases 2, 4, 6, 8 and 9) domestic stock prices increase initially while in the other cases, they register a decline. Finally, except in three cases (cases 2, 6, and 9), the disturbance is again negatively transmitted to foreign output.

IV. Reconciling the Theory and the Stylized Facts

As a first attempt to judge the empirical relevance of the theoretical model, we shall now examine to what extent the stylized facts of Section II can be interpreted within that framework. At this stage we forego formal empirical tests of the model in favor of a modest and partial reconciliation of the theory and the facts.

First, we note that the lack of co-integration between stock prices and exchange rates presumably stems from the existence of permanent real shocks that have differential effects on the countries in our sample. Sticky prices do of course render the effects of purely monetary disturbances persistent, but in principle some long-run relationship between the variables should exist in the data if only such shocks were present. 1/

1/ It is of course possible that the tests carried out are not sensitive enough to discriminate between the possibility of complete lack of long-run relationships and a high degree of persistence.

The fact that short-run movements in stock prices are positively correlated across countries can be used either to place restrictions on the parameters of the theoretical model or to draw inferences about the nature of shocks. Shocks that are positively correlated across countries will obviously give rise to similar movements in the endogenous variables. Positive correlation of shocks can be the result either of active coordination of policies or of common disturbances such as worldwide productivity shocks. In either case our perfectly symmetrical theoretical economies will respond in an identical fashion. Minor asymmetries in the real world could account for less than perfect co-movements in the data even in response to such shocks.

Common movements in stock prices could also come about in response to country-specific shocks provided that the transmission mechanism is appropriately specified. In terms of the various cases examined in the previous section we see that not all of them can generate the positive correlation of stock prices found in the data. For fiscal shocks in particular, the only ones that do are those in which domestic stock prices fall as a result of a domestic fiscal expansion. In response to monetary shocks it is true that positive transmission is the rule, but it should be noted that for several combinations of parameters the international spill-over effects are quantitatively rather small. It appears then that either some degree of explicit coordination of economic policies or a certain commonness of shocks is necessary to explain the pervasive positive correlation of stock price movements.

A prominent feature of the empirical results of Section II was that exchange rate changes do not have a stable relationship with movements of stock prices. This finding can readily be reconciled with the theoretical model and the judgment concerning the sources of shocks given in the previous paragraph. Suppose the positive cross-country correlation between stock prices is mainly the result of common shocks or coordinated policies, but that occasional country-specific disturbances give rise to exchange rate movements. Depending on the type and location of the latter, it would be possible to observe changes in the exchange rate in either direction in association with common upward or downward movements in stock prices. 1/

The finding that coincident stock price movements are most common should not be taken to suggest that there are no differences between countries at all. Both the charts in the Introduction and the evidence presented in Section II.4 indicate that relatively persistent deviations do occur. Furthermore, it was found that these deviations could be related to movements in the real exchange rate between countries but that the correlation between variations in relative stock prices and the real

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1/ If the common movement in stock prices is the result of 'transmission' of purely country-specific shocks, the weak and unstable relationships between these movements and exchange rate changes can occur if the shocks alternate between countries.

exchange rate is sometimes positive and sometimes negative. The results of the theoretical model are in conformity with these results, provided the predominant shocks are sometimes of monetary and sometimes of real origin. An expansionary domestic monetary policy will depreciate the domestic currency and lead to a relative increase of domestic stock prices, accounting for a positive correlation between (q−q*) and e. A contractionary domestic fiscal policy, on the other hand, will again lead to a real currency depreciation on impact, but also to a relative decrease in domestic stock prices. A negative correlation between (q−q*) and e would then emerge.

Can the distinction between the sources of shocks explain the major variations in the correlation between relative stock prices and real exchange rates documented in Charts 5-12 of Section II? Without pretending to offer formal econometric evidence bearing on this question we shall argue that a plausible case can be made for a provisional positive answer.

Examining first the common elements in Charts 5 and 6, there are three principal episodes that need to be explained: the early part of the sample in which the correlation between (q−q*) and e is positive, the 1977-79 period in which it is negative, and around 1983 when it is again negative. Did differential monetary disturbances dominate in the first, and fiscal (real) disturbances in the latter two? Using fluctuations in the annual rate of growth of M1 as an indicator of changes in monetary policy we computed the difference in monetary stance of the US on the one hand and Germany and Japan on the other for the period 1974 to 1987. The largest difference in the entire sample occurred in 1975 for Germany versus USA and in 1974 for Japan versus USA. Using the central government fiscal impulse measure published by the International Monetary Fund in its World Economic Outlook as a measure of policy induced real shocks we found that the largest difference between the US and the other two countries during the entire fifteen years covered by the charts occurred in 1983. The first and third of our episodes in need of explanation can thus be explained.

The negative correlation between (q−q*) and e in the 1977-79 period cannot be rationalized by our measures of monetary and fiscal impulses. Fiscal policies were not particularly asynchronous and some relatively large observed differences between German and US monetary policy is inconsistent with the computed correlations in Chart 5. A potential explanation may lie in the fact that growth in real demand was declining in the United States during this period whereas it was increasing in both Germany and Japan. 1/ To the extent that these developments were caused by differential real demand shocks not related to fiscal policy, this episode could also be accounted for.

1/ See World Economic Outlook, 1983, Appendix B, Table 5.

Turning to an (even) less systematic examination of the other charts the following points in support of our theory can be noted:

(1) The uniformly positive correlation during the period 1979-82 found in Charts 5, 7 and 8 might be attributable to monetary instability not captured by differential movements in monetary aggregates. In the beginning of this period the operating procedures of the US Federal Reserve had changed from a focus on interest rates to a focus on unborrowed reserves of the banking system. This change in operating procedure led to an increase in interest rate volatility which operators in financial markets might have interpreted as an increase in monetary uncertainty. A positive correlation between exchange rate changes and relative stock prices should then result. Why this showed up in comparisons with Germany, Italy, and the United Kingdom but not with Japan can be explained by the fact that a large difference in fiscal stance between the US and Japan occurred in 1979 judged by our fiscal impulse measures.

(2) The negative correlations in Charts 9 and 10 around 1982 are associated with a significant (both in absolute terms and in relation to other years in the sample) slowdown in demand in Germany relative to total aggregate demand in France and the UK. To the extent that this difference in demand was due to real (as opposed to monetary) factors, the theory can account for this episode.

(3) Concerning the comparison of Japan with Germany and France in Charts 11 and 12 we note that our fiscal impulse measures show the next to largest differences in the sample period in 1979 for Japan versus Germany and in 1981 for Japan versus France, coinciding with negative correlations in both cases.

Although they are episodic and incomplete, these comparisons show that our theoretical model can be made consistent with the empirical findings. This does of course not mean that other models would be inconsistent with the facts. Formal econometric tests would have to be designed to discriminate between plausible alternatives.

V. Conclusions and Suggestions For Further Research

In this paper we have documented a number of empirical regularities governing the relationship between stock prices in different countries and exchange rates. In particular, we have found a strong contemporaneous correlation between national stock price indexes in different countries, and a weaker and time-varying relationship between relative stock price movements and real exchange rates. A relatively standard two-country macroeconomic model was constructed and shown to be compatible with the empirical findings. In the model common shocks or coordination of economic policies account for the co-movements of stock prices between countries. The distinction between real and monetary shocks can explain time-variation in the relationship between real exchange rates and relative stock prices.

The analysis in this paper can be extended in a number of directions in order to examine the robustness of our conclusions with respect to changes in theoretical specification and empirical methodology.

At the theoretical level it would be useful to expand the role of stock prices by including them as an argument in the demand for money and as a determinant of investment. Friedman (1988) shows that the real value of the stock market has a significant positive wealth effect in the demand for money in the United States. Incorporating such effects could alter the dynamics of our model in important ways, especially with respect to the exchange rate.

The real value of stock prices is likely to influence investment decisions by firms and therefore the capital stock and potential output level of the economy. This important role of the stock market was excluded from our model in order to preserve some degree of analytical tractability. It would be useful to investigate how stock market linkages influence national investment rates and, thereby, the synchronization of medium- to long-term growth performance across countries. 1/

In order to make the theoretical results conform more closely to statistical hypotheses, it would be useful to introduce stochastic elements explicitly into the model. If, in addition, this were combined with more structural detail, it would be possible to investigate the effects of a greater variety of shocks and of alternative specifications of the covariance structure of these shocks. Furthermore one could, in principle, also explore the different implications of permanent versus transitory shocks. Since the solution of our relatively simple structure already presents some technical difficulties, it is of course likely that the complications suggested above will make analytical results impossible to come by and necessitate the use of numerical methods.

As far as empirical work is concerned, two main directions of research appear promising. The first would be to design and implement more sophisticated methods to measure the types, sources and magnitudes of shocks that are thought to be important for stock price and exchange rate movements. 2/ This would allow a more formal test of our conjecture that the time-varying correlation between relative real stock prices and real exchange rates is due to the occurrence of different types of shocks at different times.

1/ Andresen (1988) contains an informal but suggestive discussion of an international q-theory of investment.

2/ Appropriately modified, the method used in Bhandari, Flood, and Horne (1989) seems to be a good candidate.

A second and more ambitious direction for research is to extend the work of Cutler, Poterba and Summers (1988) to an international setting. As shown in Section III, common components of stock price movements in different markets are essentially contemporaneous. This implies, as our theory also suggests, that the relevant forcing variables for any one country could, and should, include innovations in foreign variables. A lot could potentially be learned about economic interdependence by establishing exactly how and which foreign variables effect domestic stock prices.

In this appendix we provide some detail concerning the empirical tests conducted in Section II of the main text.

1. Time series properties of the data series

In order to test for the presence of unit roots in the time series representation of each data series, the following regressions were estimated:

$$\Delta x_t = -\phi_1 x_{t-1} + u_t \tag{A1}$$

$$\Delta^2 x_t = -\phi_2 \Delta x_{t-1} + v_t \tag{A2}$$

$$x = \{P^s, P, s^{ij}, q, e^{ij}\}$$

If ϕ_1 is not significantly different from zero and ϕ_2 is, a unit root is present in the level of x but not in its first difference. In other words, x is integrated of order 1. Using the appropriate critical values for the test (i.e., those presented in Dickey and Fuller) it was found, not surprisingly perhaps, that for all variables and for all countries it was not possible to reject the presence of one unit root in each series. 1/

2. Causality tests

In order to test for the existence of lead-lag relationships across countries, Granger-causality tests were carried out on both real and nominal stock prices. 2/ Specifically, the following relationships were estimated

$$\Delta \ell n P^{si}_t = \alpha_0 + \sum_{k=1}^{6} \alpha_k \Delta \ell n P^{si}_{t-k} + \sum_{k=0}^{6} \beta_k \Delta \ell n P^{sj}_{t-k} + \sum_{k=1}^{6} \gamma_k \Delta \ell n s^{ij}_{t-k} + u^j_t \tag{A3}$$

1/ To economize on space, details of the results are not presented here. They may be obtained from the authors.

2/ It has been suggested to us that the more general VAR technique, which can accommodate more than two countries at a time, would have been preferable to the bilateral Granger tests. Given the results we have obtained, we feel confident that estimated VAR systems would show that most of the inter-country correlation between stock prices is contemporaneous.

and

$$\Delta \ell nq_t^i = \alpha_0 + \sum_{k=1}^{6} \alpha_k \, \Delta \ell nq_{t-k}^i + \sum_{k=0}^{6} \beta_k \, \Delta \ell nq_{t-k}^j + v_t^j \qquad (A4)$$

and the joint significance of the lagged values of the independent variable was examined using conventional F-tests. The results are presented in Tables I and II respectively.

Table I. Tests for Granger-Causality Based on

$$\Delta \ln P^{si}_{t} = \alpha_{o} + \sum_{k=1}^{6} \alpha_{k} \Delta \ln P^{si}_{t-k} \beta_{k} \Delta \ln P^{sj}_{t-k} + \sum_{k=1}^{6} \gamma_{k} \Delta \ln S^{ij}_{t-k} + U_{t}$$

	Country i					
	Canada	France	Germany	Italy	Japan	United Kingdom
			(Sample: 1974,1 - 1988,2)			
USA=>i	--	.072	--	--	.014	--
i=>USA	--	--	--	--	--	--
USA<=>i	*	*	*	*	*	*
GER=>i	--	--	--	--	--	.092
i=>GER	--	--	--	.011	.037	*
GER<=>i	*	*	--	*	*	*
JAP=>i	--	--	--	--	--	--
i=>JAP	.022	--	--	--	--	.014
JAP<=>i	*	--	--	*	--	*
			(Sample: 1974,1 - 1987,2)			
USA=>i	--	--	--	.095	.022	.091
i=>USA	--	--	--	--	--	--
USA<=>i	*	*	*	*	*	*
GER=>i	--	--	--	--	--	.071
i=>GER	--	--	--	.050	.025	.047
GER<=>i	*	*	--	*	*	*
JAP=>i	--	--	--	--	--	--
i=>JAP	.050	.092	--	--	--	.044
JAP<=>i	*	--	--	*	--	*

Note: USA=>i corresponds to the hypothesis that lagged values of q^{USA} are significant in the regression equation for q^{i}. i=>USA corresponds to the hypothesis that lagged values of q^{i} are significant in the regression equation for q^{USA}. USA<=>i corresponds to the hypothesis that the contemporaneous value of q^{USA} is signifiant in the q^{i} equation. Numbers refer to marginal significance levels, An * indicates a marginal significance level <.01. A lack of number indicates a marginal significance level >.10.

Table II. Tests for Granger-Causality Based on

$$\Delta \ln q^{i}_{t} = \alpha_{o} + \sum_{k=1}^{6} \alpha_{k} \Delta \ln q^{i}_{t-k} + \sum_{k=o}^{6} \beta_{k} \Delta \ln q^{j}_{t-k} + U_{k}$$

	Country i					
	Canada	France	Germany	Italy	Japan	United Kingdom
			(Sample: 1974.1 - 1988.2)			
USA=>i	--	.061	--	--	.014	.086
i=>USA	--	--	--	.073	--	--
USA<=>i	*	*	*	*	*	*
GER=>i	--	--	--	.015	--	.041
i=>GER	--	--	--	--	.028	*
GER<=>i	*	*	--	*	*	*
JAP=>i	--	--	--	--	--	--
i=>JAP	.011	--	--	--	--	*
JAP<=>i	*	*	--	*	--	*
			(Sample: 1974.1 - 1987.2)			
USA=>i	--	--	--	--	.013	.043
i=>USA	--	--	--	.090	--	--
USA<=>i	*	*	*	*	*	*
GER=>i	--	--	--	.064	.045	.026
i=>GER	--	--	--	--	.028	.046
GER<=>i	*	*	--	*	*	*
JAP=>i	--	--	--	--	--	--
i=>JAP	.027	.083	--	--	--	.021
JAP<=>i	*	*	--	*	--	*

Note: USA=>i corresponds to the hypothesis that lagged values of q^{USA} are significant in the regression equation for q^{i}. i=>USA corresponds to the hypothesis that lagged values of q^{i} are significant in the regression equation for q^{USA}. USA<=>i corresponds to the hypothesis that the contemporaneous value of q^{USA} is signifiant in the q^{i} equation. Numbers refer to marginal significance levels, An * indicates a marginal significance level <.01. A lack of number indicates a marginal significance level >.10.

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