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STOCK MARKET VOLATILITY IN OECD COUNTRIES: RECENT TRENDS. CONSEQUENCES FOR THE REAL ECONOMY. AND PROPOSALS FOR REFORM

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CONTENTS

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INTRODUCTION

This paper characterises the historical experience of volatility in major equity markets over the last thirty years. It estimates changes in the historical volatilities and measures of inter-market correlations for **15** OECD countries' stock markets over alternative periods. The focus is on gross measures of volatility; the analysis does not control for any of the events that may have contributed to financial returns volatility. Indeed, the results of a study by Schwert **(1989)** suggest that the contributing sources of volatility are not easily identifiable.

After reviewing changes in historical volatility and market interrelationships, the paper considers the macroeconomic consequences of excessive volatility. It discusses some of the financial market reforms that have been proposed in the United States to attenuate stock price variability; these include proposals that attempt to limit volatility by imposing temporary trading halts, by limiting the legal leverage available to investors in financial assets, by altering exchange trading practices to accommodate volume, and by raising the transactions costs of financial trading.

The analysis suggests that the past three decades have coincided with increases in the average volatility of stock returns in most OECD countries. However, measures of average monthly volatility alone give a misleading impression. Focusing on the late **1980s,** when volatility can be measured at higher frequencies, it is apparent that volatility during periods of "normal" market conditions has not changed much. Instead, average volatility has increased due to transitory periods of abnormally high volatility. Following these high-volatility episodes, market volatility measures quickly revert back to much lower "normal" levels.

The empirical measures characterising the interrelationships among OECD countries' equity market returns suggest that these markets have become more interrelated in the last thirty years. Correlations between the returns on countries' stock market indices have, on average, become stronger. Similarly, the correlations between stock market volatilities have also grown – that is, it has become more common for world equity markets to experience bouts of above-average volatility concurrently. Further, evidence from the late **1980s** suggests that inter-market return correlations and volatility are linked – market index movements become more highly correlated across countries when market volatility is high.

I. TRENDS IN STOCK INDEX VOLATILITIES AND RETURN INTERRELATIONSHIPS

A. Measurement issues

The most common measure of stock return volatility is a sample standard deviation of returns. When daily data are available, estimates of the sample standard deviation of daily returns calculated by month, or alternatively, calculated over a rolling sample period of fixed size – a so-called "root-t roll" – serve as useful measures for characterising the evolution of volatility. Unfortunately, for many countries, long samples of daily data on stock market indices are not readily available. Consequently, analysis of longer-term volatility movements must be based on monthly data. If the objective is to study the time-variability of volatility using monthly data, the sample standard deviation is not an appropriate volatility estimator as a single volatility estimate requires many months of data. The sample size requirements of the standard deviation estimator limits the scope for investigating short-term movements in volatility and the correlation patterns among national market volatilities. Schwert (1989) has developed an estimator that produces monthly volatility estimates from monthly return data. The Schwert estimator is based upon the robust estimation techniques proposed by Davidian and Carroll (1987); it has properties similar to the autoregressive conditional heteroscedasticity (ARCH) estimator of Engle (1982). A more complete discussion of the Schwert estimator is given in the technical appendix.

The data used in the analysis are monthly price indices for 15 countries taken from the OECD's financial market data base. Beginning in the 1980s, daily data are available for a limited number of countries, and for a shorter period, intra-day data are available for the U.S. S&P 500 index. The higher frequency data is used to supplement analysis of monthly data of the 15-country sample. The country indices are not identical in the daily and monthly data samples. A more complete description of the data is given in the technical appendix.

From the individual country monthly index returns, monthly measures of return volatility are estimated using the Schwert technique. The monthly volatility estimates are analysed for individual countries and the cross-country relationships are measured by estimating both the correlations among the markets' returns and the correlations among markets' monthly return volatility estimates.

The 30-year sample is split into fixed and floating exchange rate sub-samples from which the long-term changes in volatility and market interrelationships are identified. The shift from fixed to floating exchange rate regimes coincides with the beginning of major developments in all financial markets. Moreover, economic theory predicts that a change in exchange rate regimes might alter the degree to which foreign disturbances are transmitted to a country's domestic economy and so to its stock market'. Although the empirical evidence provides no clear guide as to the direction or magnitude of the effects (Lastrapes and Koray, 1990; Hutchison and Walsh, 1991), these considerations suggest that the changed exchange rate regime represents a suitable partition of the 30-year sample. In addition, we analyse in detail data from the 1980s and further supplement the investigation with an analysis of high-frequency data for the U.S. S&P 500 stock index.

B. Stock returns volatility

Estimates of the average monthly stock-index return volatilities for alternative sample periods are reported for all 15 countries in Table 1. These show a tendency toward increasing volatility over the thirty-year period in most OECD countries. The average volatility across these indices increased almost 16 per cent between the fixed- and floating-rate periods. The sample estimates from the first and second halves of the 1980s show that return volatility increased on average almost 10 per cent over the decade.

The highest average monthly volatility was recorded in the post-1985 sample for 11 of the 15 OECD countries. However the five-year average volatility estimates are misleading as the elevated average is caused by transitory increases in volatility. Chart 1 plots the Schwert monthly volatility estimates for five major national markets over the 1980s. The transitory peaks are evident in Chart 1, but become much more pronounced when volatility is measured at a higher frequency. Chart 2 plots daily estimates of stock returns volatility calculated from daily data for eight countries, using the standard deviation of returns from a 30-trading-day rolling sample. These measures of volatility show definite transitory spikes in return variability coinciding with the October 1987 global stock market crash and the October 1989 "mini-crash". These plots do not suggest that returns variability in these countries have positive time trends. Following these transitory peaks, volatility reverts toward much lower levels.

Table 1. Average monthly stock index return volatility[1]

Percentage standard deviations

	Fixed exchange rate (1961-70)	Floating exchange rate (1974-89)	1980-84	1985-89
Belgium	3.28	3.60	3.68	3.72
Canada	3.85	4.26	4.71	3.81
Finland	3.15	3.18	3.16	3.50
France	4.83	5.66	5.39	5.90
Germany	3.94	3.52	3.18	4.02
Ireland	3.42	5.13	4.69	5.44
Italy	5.08	5.43	5.25	5.65
Japan	3.48	3.01	2.63	3.47
Netherlands	3.97	3.94	3.90	3.85
Norway	4.20	5.83	5.95	5.79
Spain	2.98	5.14	4.52	5.61
Sweden	3.46	4.65	4.88	4.81
Switzerland	4.30	3.92	3.53	4.37
United Kingdom	3.68	4.32	3.79	4.31
United States	3.10	3.43	3.30	3.56

1. Monthly return volatilities are estimates of the standard deviation of returns, by month, from the Schwert volatility estimator. For details on the composition of the indices and definition of the Schwert estimator, see the Technical Appendix.

Chart 1. **Monthly stock returns volatility**

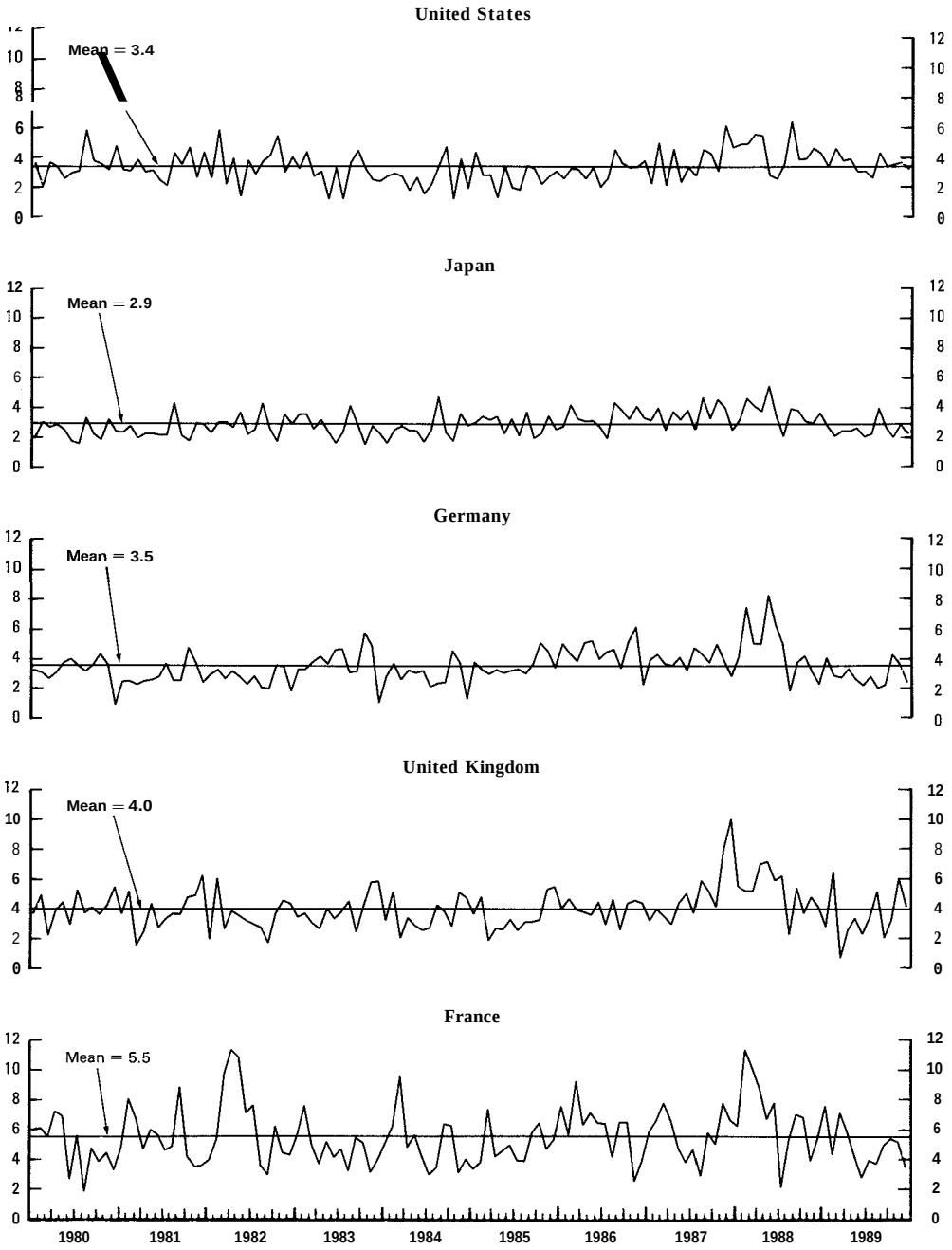
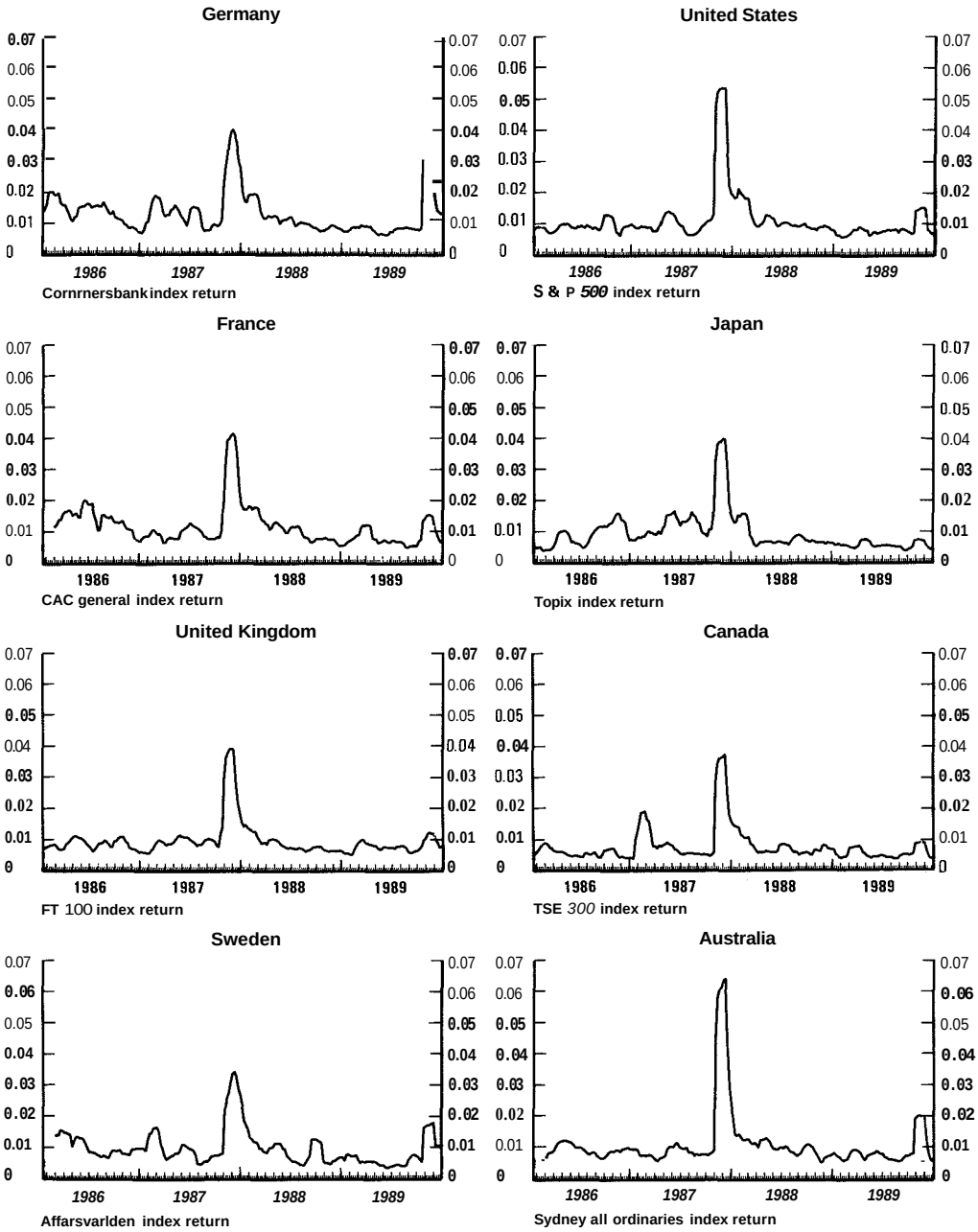


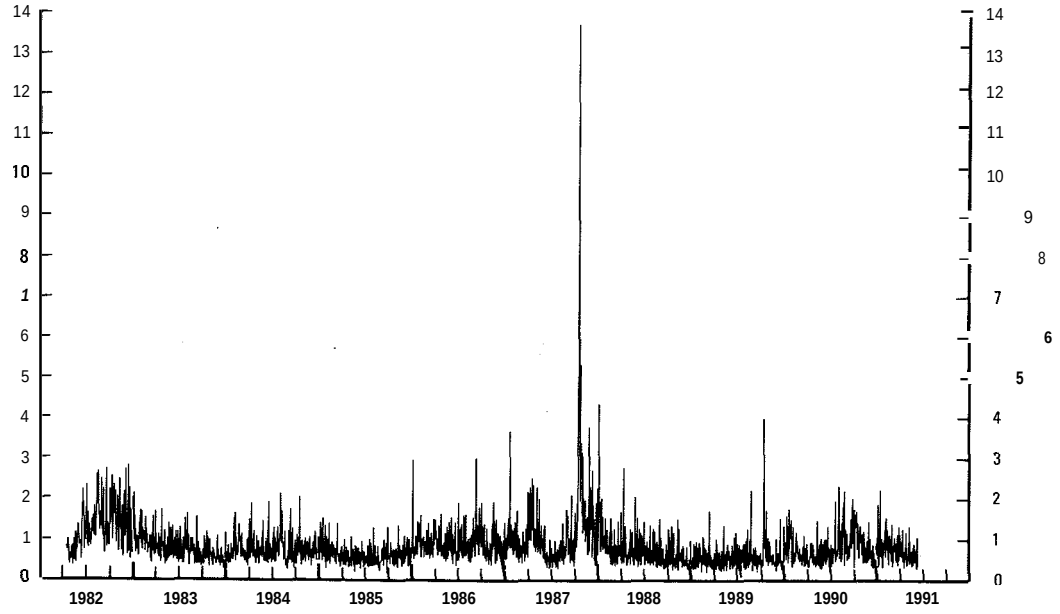
Chart **2. Stock return volatility**
Thirty-day rolling standard deviation



This pattern of transitory increases becomes more pronounced when volatility is measured using data within a trading day. Chart 3, reproduced from Kupiec (1990), plots daily volatility estimates for the U.S. S&P 500 index estimated from intra-day data. The chart exhibits mean reversion in volatility and indicates no positive trend in volatility during "normal" market periods over the 1980s.

The increase in the occurrence of transitory periods of excessive volatility has given many the impression that average volatility levels have substantially increased. If these abnormal episodes are becoming more common, average volatility has indeed increased. If, however, these events remain rare, and the late 1980s happened to be an exceptional period, average volatility exhibits no significant time trend. Although this may appear a matter of semantics, the distinction is critically important and not directly testable. Whether or not the late 1980s represent an "outlier" with respect to underlying stock market volatility trends is central to determining whether or not stock market volatility has increased. It is the focus of the debate concerning the effects of financial liberalisation and innovation on financial asset return volatility. Whether or not the development of financial markets and instruments has made periods of transitory stock market instability more likely is a topic of considerable debate.

Chart **3. S & P 500 intra-day volatility estimates**



C. Interrelationships among national stock market returns

This section examines how the correlations between stock market returns and correlations between return volatilities have changed over time. It also analyses the effects of volatility on stock market correlations using daily data from the 1980s.

Dwyer and Hafer (1988) study changes in the correlations among selected stock market indices. Their results show that the markets have been more closely linked since the abolition of fixed exchange rates in the early 1970s. Bennett and Kelleher (1988) estimate intermarket return correlations in the 1970s and the 1980s. Their results indicate that the international linkages among equity markets have become slightly stronger over this period.

Empirical evidence suggests that the correlations between market returns increase when volatility is abnormally large. Bennett and Kelleher (1988) present evidence of a statistically significant positive linear relationship between the correlations of international markets' returns and the volatility of returns in markets that open and trade earlier in the day. Dwyer and Hafer also present evidence that intermarket correlations increased during periods of high volatility (specifically the October 1987 crash). Hamao, Masulis and Ng (1990) find that large price changes in a market tend to transfer or "cause" large price changes in markets temporally following it in the trading day.

An explanation for the empirically observed positive relationship between market correlations and volatility is offered by Neumark, Tinsley and Tossini (1991). It attributes the positive relationship to transactions costs that limit the profitability of international arbitrage activities. Because international transactions are costly, profit opportunities must exceed a threshold level before arbitrage is undertaken. Without the international arbitrage, returns are less highly correlated than they would be in a transaction-costless market. There are many arbitrage trade dead-zones when markets are relatively calm. In instances of large price changes, arbitrage between markets becomes profitable and intermarket returns become more highly correlated.

An explanation for the high correlations observed between market volatilities is advanced by King and Wadhwani (1990). This explanation is based upon a model of how investors react in their domestic markets to price changes they observe in foreign markets. In their model, information arriving to an individual market has two components: one component is economic information that has implications for global equity prices; the second component is market-specific information that is "noise" from the perspective of other markets around the world. Information is revealed sequentially as markets open and close throughout the trading day.

In the King-Wadhwani model, an investor in an equity market that **is** about to open "midday" in the 24-hour trading day could analyse all the information announcements that have cumulated from the last close of his domestic market and estimate the impact on his home market's opening price. Alternately, he could use the price changes in the markets that have opened and traded earlier in the trading day to estimate the likely price impact of the new information on his domestic market opening. In the second approach, abnormally large foreign price changes, whether caused by an abnormally large country-specific information component or a global information release, will have the same estimated domestic market price impact. Because of this, large price changes tend to be transmitted from market to market.

D. Stock index return correlations

Table 2 summarises the estimates of the market return correlations for the 15 **OECD** countries' stock market indices for the alternative sample periods. The individual correlation estimates appear in Tables A1 and A2 in the Technical Appendix.

Table 2. **Correlations among stock markets' returns in 15 OECD countries**

A. Summary statistics

Fixed exchange rate sample (January 1961/December 1970)	
Average pairwise correlation estimate	0.195
Sample variance of pairwise correlations	0.029
Floating exchange rate sample (January 1974/December 1989)	
Average pairwise correlation estimate	0.236
Sample variance of pairwise correlations	0.040
Early 1980s (January 1980/December 1984)	
Average pairwise correlation estimate	0.212
Sample variance of pairwise correlations	0.035
Late 1980s (January 1985/December 1989)	
Average pairwise correlation estimate	0.331
Sample variance of pairwise correlations	0.041

B. Summary of the estimated changes in pairwise return correlations

	Fixed-to-floating	Early-to-late 1980s
Estimated number of increases	69	79
Estimate of average increase	0.114	0.189
Estimated number of decreases	37	26
Estimate of average decrease	−0.075	−0.096

The average pairwise correlations reported in Table 2 indicate that stock returns have become more highly (positively) correlated across markets over time. The average pairwise correlation among these 15 countries' stock returns increased over 50 per cent between the first and the second half of the **1980s.** An examination of the individual correlation estimates indicates that the correlations between G7 countries' indices became measurably stronger earlier, whereas the correlations among the non-G7 country indices increased for the most part during the late **1980s.** The estimated correlation changes for the **1980s** indicate that, for the G7 markets, returns have become only slightly more positively correlated over the period whereas for the other markets, return correlations have increased more substantially.

E. Correlations among stock index return volatilities

Table 3 summarises the estimates of the pairwise return volatility correlations for the alternative sample periods. Both the individual measures (not reported) and the summary measures reported in Table 3 indicate that the correlations between the volatilities of monthly returns have increased over time. The estimates show that volatilities, particularly among the major markets, were much more strongly positively correlated in the second half of the 1980s as compared with the first half of the decade. The average pairwise correlation between the U.S., U.K., Japanese, French and German markets increased by more than 0.32 over this period. The increase in the volatility correlations implies that the probability that the major markets simultaneously experience above-average volatility was higher in the second half of the 1980s. This characterisation remains true even if the 1987 October crash is omitted from the estimation sample.

Table 3. **Correlations among estimates of stocks markets' monthly return volatility in 15 OECD countries**

A. Summary statistics

Fixed exchange rate sample (January 1961/December 1970)	
Average pairwise correlation estimate	0.075
Sample variance of pairwise correlations	0.030
Floating exchange rate sample (January 1974/December 1989)	
Average pairwise correlation estimate	0.130
Sample variance of pairwise correlations	0.017
Early 1980s (January 1980/December 1984)	
Average pairwise correlation estimate	0.066
Sample variance of pairwise correlations	0.029
Late 1980s (January 1985/December 1989)	
Average pairwise correlation estimate	0.203
Sample variance of pairwise correlations	0.034

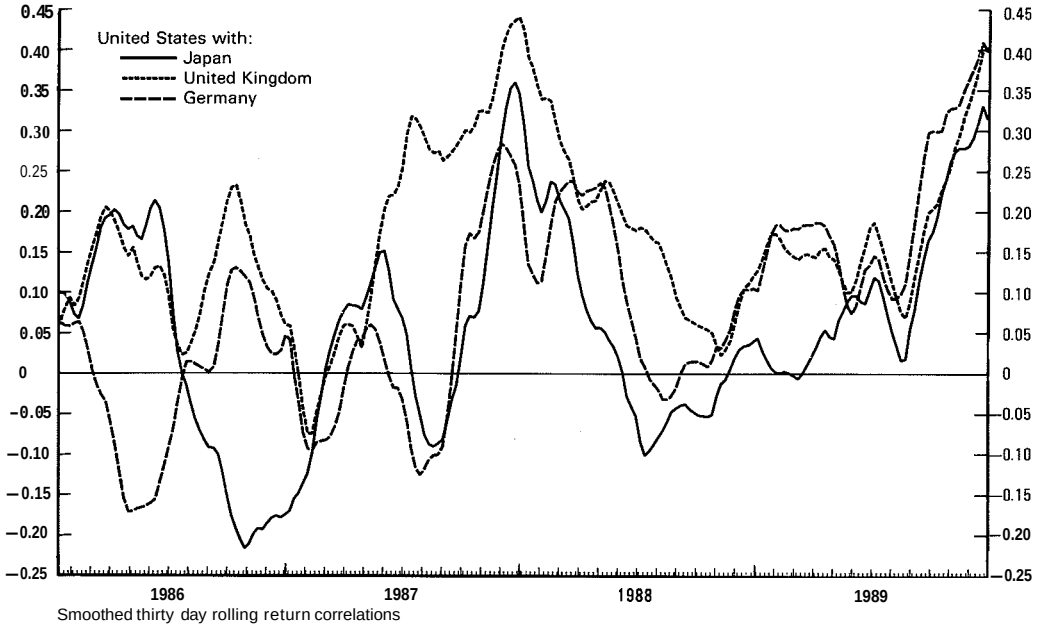
B. Summary of the estimated changes in pairwise return correlations

	Fixed-to-floating	Early-to-late 1980s
Estimated number of increases	66	73
Estimate of average increase	0.147	0.238
Estimated number of decreases	39	32
Estimate of average decrease	−0.099	0.108

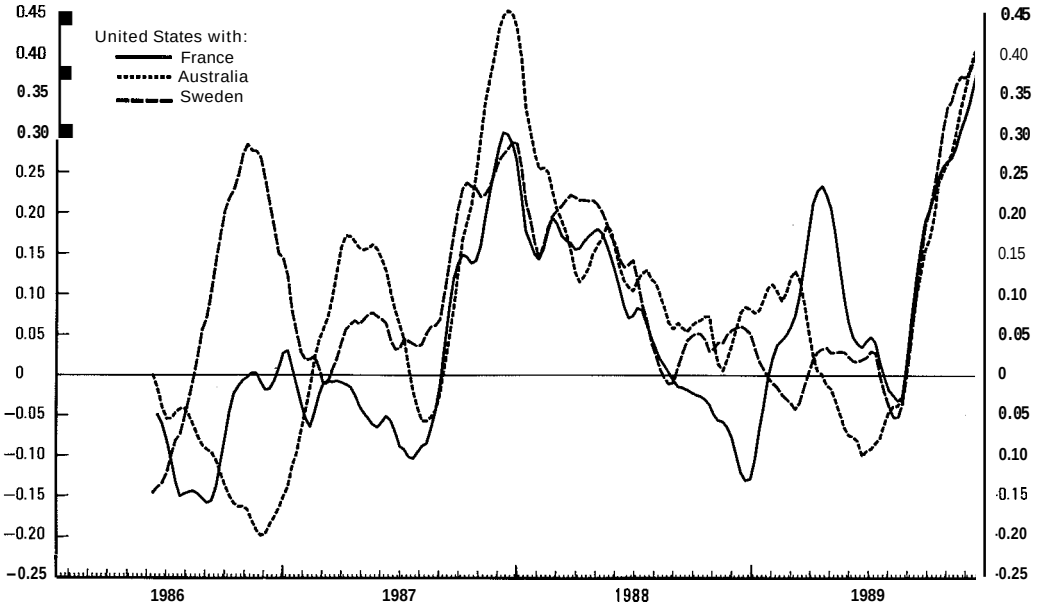
F. Return correlations during crisis periods

As return volatility increases, it becomes more likely that markets will move together, as large price moves are interpreted as global news and as large price

Chart 4. Stock return correlations



Smoothed thirty day rolling return correlations



Smoothed thirty day rolling return correlations.

changes move relative prices through the non-trading zones induced by the costs of international transactions. Chart 4 plots the smoothed values of 30-day rolling return correlation estimates for 6 different countries' indices with the return on the U.S. S&P 500 stock index. The increase in correlations following the October 1987 and October 1989 crashes is evident in all the plots. During these heightened volatility periods, markets were much more positively correlated. Outside these periods, inter-market correlations are substantially lower and at times even become negative.

II. REAL AND FINANCIAL MARKET CONSEQUENCES OF FINANCIAL MARKET VOLATILITIES

Excessive financial market volatility may have important effects on real economic activity and the functioning of capital markets. Periods of extreme volatility may strain the financial market clearing and settlement infrastructure, causing a loss of investor confidence in the solvency of trade-counterparties, and thereby reduce market participation and liquidity at a time when it is most needed. Such a loss of confidence would intensify volatility and could potentially lead to a temporary breakdown in organised trading. Indeed some attribute the "free fall" in U.S. stock prices on 19 October, 1987 to such investor concerns (Gennotte and Leland, 1990). Such a severe loss of investor confidence would certainly have effects on the cost and availability of investment capital. The October 1987 stock market crash heightened governmental interest in the integrity of financial markets, and subsequently, measures designed to reduce the systemic risk of financial markets have been proposed and implemented[2].

Aside from the issues of market integrity and counterparty risk management, excessive volatility affects the prices of, and required rates of return on, financial assets. Financial asset pricing models indicate that the equilibrium risk premia on risky asset returns are increasing functions of their non-diversifiable conditional return volatility. Higher required rates of return imply lower financial asset values. Empirical evidence supports the theoretical predictions, finding that ex-post rates of return on financial assets are positively related to non-diversifiable return variability. Neoclassical investment theory predicts that the higher discount rates caused by excess volatility will increase corporate costs of capital, thereby leading firms to reduce their real investment spending, other things constant.

The theoretical link between stock market valuation and investment decisions is summarised in the q-theory of investment (Tobin, 1969; Hayashi, 1982). According to neoclassical theory, when stock prices are high, firms' q-values – the market value of a firm divided by the replacement value of its capital stock – are greater than 1 and firms are encouraged to expand their investments in real assets. Holding other things constant, in long-run equilibrium when firms are correctly valued by an efficiently functioning securities market, q-values should tend toward unity as firms continue to invest until the marginal dollar invested earns only a competitive risk-adjusted rate of return.

Although in theory stock return volatility may have important effects on required rates of return and corporate equity costs of capital, the neoclassical link between the financial and the real side – that changes in the equity cost-of-capital cause changes in firms' investment demands – is not strongly supported empirically. The empirical

macroeconomic evidence from the United States suggests that in the aggregate, accelerator-based models explain investment spending at least as well as neoclassical cost-of-capital models (Clark, 1979). In the accelerator view, demand is the most important "cause" of investment and cost-of-capital issues are of second-order importance.

In addition to econometric models of aggregate investment behaviour, support for the accelerator view comes from research into financing-constrained theories of investment. Fazzari, Hubbard and Petersen (1988) investigate investment behaviour under the "financing hierarchy" theory which states that, owing to issuance, institutional, and information asymmetry costs, firms have well-defined rankings of the costs of different sources of project financing. In this ranking, internally generated funds, or cash flow, are the cheapest source, and equity issuance is the most expensive source of investment financing. Fazzari ***et al.*** find that cash flow is empirically more important in explaining investment than are equity costs of capital, as measured by firms' q-values. Analogous to aggregate accelerator models of investment, final demand generates both profitable investment opportunities and firm cash-flow which generates the cheapest source of funds for investment. It is not that the cost of capital is unimportant, rather that the cost of new equity issuance is sufficiently high so that it is rarely a source of investment finance. Consequently, marginal changes in a firm's equity value have little effect on new share issuance or a firm's investment decisions.

Empirical evidence that equity price movements help explain aggregate investment behaviour has been provided by Barro (1990). Barro finds that lagged values of real stock price changes have significant explanatory power for aggregate investment series in the United States and Canada. He finds that real stock price changes dominate aggregate q-variables as explanatory variables in investment models and that stock prices retain significant explanatory power even when cash-flow variables are introduced into the model.

Equity prices may be an important explanatory variable in empirical investment models because they have independent influences on managers' investment decisions, or alternatively, they may be important simply because they are a good statistical summary of the fundamental information that managers use to formulate their investment policy. The second hypothesis, the so-called "passive informant" view of the stock market, assigns no independent role for equity prices. Instead, equity prices are helpful in predicting future investment behaviour simply because they are correlated with the expectations of future fundamentals upon which managers base their investment decisions. Under this hypothesis, neither the equity value of a firm nor the level of the equity market convey new information to a firm's manager. According to the passive informant hypothesis, the stock market is "a side show"; stock prices or a firm's q-value do not independently affect investment. If the econometrician had access to the appropriate data on the expectations of economic fundamentals, stock prices would add no further information. An implication of this hypothesis is that stock price deviations from fundamentals do not misallocate real investment. Managers ignore overvalued as well as undervalued equity prices when formulating their investment plans.

Morck, Shleifer, and Vishny (1990) investigate the passive informant hypothesis using cross-section and aggregate data for the United States. They find that cross-sectionally, after controlling for firm fundamentals, stock returns add little explanatory power (about **4** per cent) to models explaining the growth rate of investment or to models explaining the timing and the size of new debt and equity offerings. In aggregate data, they conclude that it is likely that the stock market is a predictor of funda-

mentals, not a part of the set of basic economic information. That is, after controlling for fundamentals, the level or change in stock prices has little independent explanatory power in an aggregate investment equation. They conclude that equity prices have little independent influence in determining the long-run investment and financing behaviour of firms; rather, the equity market is a "side show" and equity prices convey little useful independent information to firm managers.

The evidence from micro-level survey studies does not suggest that equity prices have a strong independent role influencing the investment and financing plans of U.S corporations. A study by the New York Stock Exchange (NYSE, 1990) includes a survey of investors, and corporations' attitudes and opinions about the conditions and investor climate in the stock market. Given the intense media and regulatory attention paid to stock market volatility, the survey's results are surprising. When corporate representativeswere asked their concerns about the stock market, only **15** per cent of those responding expressed a concern about the level of market volatility. 50 per cent of the corporations surveyed responded that the level of market volatility would not affect their equity or debt offering plans, and only 20 per cent indicated that the current stock market condition would affect their future financing plans. Although few firms actually issue equity in a given year, the survey responses do not suggest that the heightened volatility episodes have generated significant new financing difficulties for corporate financial officers.

Table **4** reports the results of a regression of monthly non-financial equity issuance in the United States on its lagged value, and the deviations of the S&P **500's** price-earnings ratio and monthly stock return volatility from their sample averages. The results suggest that equity issuance increases when market price-earnings ratios are relatively high, and issuance is reduced by above-average market volatility, although the latter effect is not statistically significant. A more intensive empirical investigation is required before the importance of volatility is dismissed. However, on balance these preliminary results do not suggest that temporary periods of volatility have strong effects on firms' ability to raise equity capital.

Financial market volatility may have indirect effects on the real economy through its effects on consumer and investor expectations. Financial price volatility will reflect the volatility of the underlying economic fundamentals and, as some have suggested, it may reflect excess trading-induced factors as well. If the contributing sources of volatility are not identifiable, episodes of heightened volatility may be interpreted as an indication that the uncertainties regarding the values of future economic fundamentals have increased. Increased financial market volatility could induce a **loss** of consumer confidence and indirectly affect real consumption and investment decisions.

Panel B in Table **4** reports the results of a regression of the University of Michigan's Survey Research Centre's consumer sentiment index for all U.S. families on the lagged index's value, the contemporaneous month's U.S. stock market return, volatility, and **3** lagged values of monthly stock returns volatility. The regression results show no evidence of an association between higher stock returns volatility and reduced consumer confidence. Although only preliminary at best, these results do not indicate that transitory periods of volatility in stock prices are likely to have major impacts on consumer confidence.

The lack of a strong link between temporary periods of heightened financial market volatility and significant real effects is illustrated by events subsequent to the Octo-

Table 4. Economic effects of temporary increases in equity market volatility

A. Sensitivity of equity issuance to market volatility conditions

Variable	Estimate	T-statistic	P-value
Constant	596.50	5.41	0.01
PIE ratio	38.99	2.21	0.03
Volatility	43.76	0.74	0.46
Lagged equity issuance	0.62	9.78	0.01

Note: Equity issuance is monthly non-financial equity (May 1976-December 1989) from the Federal Reserve Bulletin. P/E ratio is the deviation from the sample average of the S&P 500's price-earning ratio. Volatility is the deviation from the sample average of the Schwert monthly volatility estimate for the U.S. equity market estimated from OECD data. The P-value is the probability level at which the null hypothesis of a zero coefficient is rejected.

B. Estimate of stock returns volatility effects on consumer confidence

Regressor	Estimate	T-Statistic
Constant	78.28	9.67
Market return	0.15	0.46
Market volatility	-0.71	0.42
Market volatility lagged one month	-0.21	0.13
Market volatility lagged two months	-0.12	0.1
Market volatility lagged three months	-0.14	-0.1

Note: Consumer confidence is measured by the University of Michigan's Survey Research Center's Consumer Confidence Index for all families. The data is monthly from January 1976 through May 1990.

ber 1987 and October 1989 stock market crashes, as well as equity market crashes which occurred in Far Eastern markets in 1990. Estimates of aggregate consumption models for the U.S. economy indicate that an extra "permanent" dollar of stock market value translates into an extra 3 to 7 cents of real consumption expenditures (Pearce, 1983; Brayton and Mauskopf, 1987). The evidence from the October 1987 and 1989 crashes suggests that these episodes of elevated volatility did not alter agents' expectations of the permanent value of their stock holdings. Although these two crashes represent the highest volatility periods since the 1930s, neither has been associated with significant deterioration in real consumption or investment activity.

Similar to the U.S. experience, the 1990 Japanese stock market crash, although it has had significant and potentially long-term effects on Japanese financing behaviour, had apparently little immediate impact on Japanese domestic demand. Over the first four months of 1990, the Japanese equity market fell almost 30 per cent, yet Japanese retail and auto sales remained strong well into the summer months. Following a brief recovery in April, the Japanese market continued declining, but again the declines had little direct impact on domestic demand which slowed only with the combined effects of a tight monetary policy and the external shocks associated with the summer 1990 Gulf Crisis.

Other Far Eastern equity markets suffered severe losses in 1990 without devastating effects on domestic activity. Between 12 February and 1 October, the Taiwanese

stock market index lost 80 per cent of its value, a **loss** equivalent to about 1.5 times Taiwan's 1989 GNP. Despite the **loss,** the Taiwanese economy continued to grow at a 5 per cent rate, with little evidence of a pending deterioration. The South Korean stock market lost almost **40** per cent of its value before recovering in mid-September 1990. As in the other cases, South Korean growth remained strong through the remainder of the year with a continued strong outlook for 1991.

Although economic theory may predict a linkage between volatility in financial markets and real economic activity, the empirical evidence suggests that the linkages may not be all that strong. The empirical evidence to date does not indicate that the higher levels of volatility experienced in the second half of the 1980s have had strong negative influences on aggregate real economic activity. Nevertheless, even if volatility does not have strong or obvious real-side effects, it does have significant wealth redistribution effects which may be important to governments and regulators.

Unless it can be established otherwise, it is generally assumed that a competitive market structure provides an optimal allocation of resources. Secondary equity markets are, in many ways, among the closest existing analogues to the theoretical competitive market. Despite this, it is common to interpret increased volatility as evidence that something has gone wrong in these markets. Until the sources of excess volatility are better understood, it is impossible to say with any confidence that higher volatility is linked to developments that have made equity markets less efficient. Although it may be difficult to see how increased volatility can be generated by beneficial market developments, a study by Froot and Perold (1990) suggests that stock price volatility has increased because new financial trading practices have increased the efficiency with which market-wide information is processed by market participants.

III. POLICY MEASURES TO REDUCE VOLATILITY

Aside from foreign exchange or monetary policy operations, financial policy rarely takes the form of direct government purchases or sales intervention in a market. Financial policy involves rules for exchange trading and dealer/market-maker behaviour, rules of disclosure and sales practice, approval of new product trading, rules of prudential lending requirements and the level of direct taxes for transacting in financial instruments or on financial exchanges. Since the October 1987 stock market crash, rules and proposals aimed at reducing volatility have been offered in the United States in virtually all of these areas. October 1987 was the catalyst for new rules for the exchange trading of stocks, options and index futures. Among these rules are coordinated circuit breakers, and exchange rules governing the trading of "exchange stock portfolios". In this section, we discuss some of the rules and proposals as they have developed in the U.S. markets.

A. Circuit breakers

Circuit breakers are a series of predetermined temporary price limits. When the market falls below the limit amount, trading is halted for a predetermined period of time.

In the stock market, all trading is halted when a price index reaches the limit. In the futures markets, trades can occur only above the limit price. The Brady Commission, the presidential commission formed to study the October **1987** market crash, strongly recommended circuit breakers:

> "First, they limit credit risks and loss of financial confidence by providing a time-out amid frantic trading to settle up and ensure that everyone is solvent. Second, they facilitate price discovery by providing a 'time-out" to pause, evaluate, inhibit panic, and publicise order imbalances to attract value traders to cushion violent movements in the market. Finally, circuit breaker mechanisms counter the illusion of liquidity by formalising ... that markets have a limited capacity to absorb massive one-sided volume'.
>
> (Brady Commission Report, p. 66)

The arguments in favour of circuit breakers are based on the premise that substantial intra-day market price swings are not consistent with underlying fundamentals or market efficiency. If large price movements are due to illiquidity or irrationality, the circuit breakers are supposed to give rational traders and providers of liquidity time to enter the market.

However, several theoretical arguments based on market efficiency suggest that price limits or circuit breakers may have undesirable effects. They interfere with the market's price discovery function and deprive traders of hedging options, thereby reducing liquidity in complementary markets. Once trading causes prices to approach the circuit breaker limit, they may encourage prices to move to the limit more quickly as traders rush to beat market closure in order to eliminate the corresponding uncertainty about the value of their holdings – the so-called "gravitational effect" of price limits.

Even if circuit breakers could be roughly co-ordinated across markets in terms of equivalent price movements, in practice futures prices adjust much more quickly than do cash market indices. Consequently, futures circuit breakers may be triggered while the cash and options markets remain open. This is exactly what occurred on 13 October **1989,** the first time both S&P 500 index futures price limits were triggered.

Did circuit breakers attenuate volatility in their maiden trial in October **1989?** There is no consensus evaluation. The **U.S.** Securities and Exchange Commission's (SEC) report on the events of 13 October **1989** contends that the temporary closure of the futures market reduced the volatility in the cash market:

> "The imposition of the CME's 12-point price limit for the S&P futures coincided with a sharp drop-off in the level of program selling on the NYSE and a reduction in the rate of price decline in NYSE stocks. After the price limit expired at 3:30, the rate of the price decline in NYSE stocks increased substantially. While a direct causal relationship is difficult to establish, at a minimum, the Division's findings do not indicate any harm to the markets attributable to the imposition of the circuit breaker mechanisms ...".
>
> (SEC, **1990,** p. ES-2)

The **U.S.** Commodity Futures Trading Commission's (CFTC) report on the 13 October "mini-crash" does not concur with the findings of the SEC's study,

> "Shock absorbers [circuit breakers] do not appear to have moaerated intra-day volatility. The average levels of volatility did not decrease in the limit periods ...

Instead, there is evidence that a binding circuit breaker in one market is associated with increased volatility in unconstrained markets."

(CFTC, 1990, p. 125)

McMillan (1990) has, to date, made the most comprehensive study of the impact of circuit breakers on 13 October 1989. He concludes that circuit breakers impaired liquidity in the futures market and likely had strong gravitational effects as well. Studying trade-to-trade futures price data, McMillan finds that price changes were much larger after the first S&P 500 index future's circuit breaker was tripped. Such an increase in the size of trade-to-trade price changes was not characteristic of days with similar volatility prior to the adoption of circuit breakers. He also finds long series of price runs – consecutive price changes of the same sign – in the trades immediately preceding the circuit breaker trigger. Long price runs are not a characteristic of trade-to-trade price changes on days with similarly large price falls before circuit breakers were adopted. The existence of price runs is consistent with the hypothesis that circuit breaker price limits have a gravitational effect on prices.

Although the studies disagree on their assessment of the effectiveness of futures market circuit breakers, the October 1989 experience shows that when the futures market closed, volume was transferred to the cash market, options markets, and the remaining futures contracts open for trading. The closure of the futures market also impaired the functioning of the option market as option market makers were unable to hedge their positions using stock-index future contracts. In addition, when the options markets did close, attempts to re-open them late in the afternoon were unsuccessful. From this single incident, it would appear that the coordination of the timing of the circuit breakers might be as important *a* consideration **as** the co-ordination of the magnitudes of the moves that trigger temporary price limits.

B. Exchange stock portfolios

One of the major lessons of the October 1987 market crash was the illiquidity of the cash market in the face of large sell orders by institutions. It is unrealistic to entertain the idea that a specialist could have access to capital sufficient to stabilise prices in a market dominated by institutional sell programs. The large price reversals in S&P 500 stocks attributable to order imbalance on 19 and 20 October documented by Blume, MacKinley and Turker (1989) are direct evidence of the short-term lack of liquidity in this market.

In order to relieve the specialists of some of the institutional trade-induced pressures on volatility, the **NYSE** created the "exchange stock portfolio" **(ESP).** The ESP is an instrument that allows an investor to buy or sell the entire S&P 500 stock index portfolio of shares with one order. Within the **NYSE,** ESPs are unique in their market maker structure. Unlike individual stocks that have a simple specialist, the market for **ESPs** is made continuously by competing dealers. In contrast to a program trade that sends individual stock orders to specialist posts, an **ESP** order is satisfied at the competitive market maker quote, thereby avoiding the direct stock order flow to exchange specialist posts[3].

It is the intention of the NYSE that ESPs should become a preferred vehicle for institutional portfolio trades, and the unique competitive market maker system would take the institution-generated liquidity pressures off the individual stock specialists. By any measure, the success of **ESPs** to date has been discouraging. Trading in ESPs began in October **1989.** Even on relatively volatile days when there has been heavy volume of index arbitrage program trading, ESP volume has been light.

The ESP represents both a new product and a new market making structure for the NYSE. Despite its disappointing performance, it is notable that an ESP is an innovation designed to accommodate trading, not limit it.

C. Sunshine trading

Another set of proposals aimed at limiting the volatility impacts of transitory periods of heavy institutional selling are so-called "sunshine trading" disclosure requirements. Dynamic hedging strategies, so-called portfolio insurance programs, are positive feedback trading rules; that is, they require an investor to purchase additional shares or futures contracts when the market rises in value and to sell shares or futures when the market falls. If a significant portion of investors follow such programs, their purchases and sales may exacerbate market movements. Because of the existence of such strategies, otherwise modest market declines may trigger sales by large insured institutional portfolios, putting further downward pressure on prices. Gennotte and Leland **(1990)** develop a model where the pressures of dynamic hedging strategies produce discontinuous jumps in stock prices similar to the experiences of the October **1987** stock market crash. The discontinuous price movements are a consequence of informational problems caused by dynamic hedging strategies. The informational problem in the Gennotte and Leland model is a form of the informational externalities associated with the use of so-called "synthetic securities".

Synthetic securities are a by-product of financial engineering. A synthetic security is not a true security, rather it is **a** portfolio of securities assembled in proportions that vary over time in a precise manner determined by a financial pricing relationship. Using theoretical pricing models, the cash flows of a particular security can be replicated using a portfolio of other securities. For example, the cash flows of a simple put option can be replicated using a portfolio of default-riskless bonds and the financial instrument underlying the option being replicated[4]. The portfolio shares of the underlying security and debt are varied over time according to conditions implicit in a theoretical option pricing model. Portfolio insurance in its simplest form is a set of trading rules that creates a synthetic put option for the portfolio of interest.

Grossman **(1988)** discusses the externalities associated with the trading of synthetic financial assets. When an investor purchases a stock-index option, his expectations are reflected in the market price, strike price, and change in open interest for the option purchased. If alternatively, the investor were to synthetically create the desired option's cash flow using stock-index futures and treasury securities, there is no observable market price or volume data to signal his expectations and implied demand for insurance to other market participants. In effect, if all investors were to insure their portfolios with put options, the aggregate demand for insurance would be represented in the market data on these options; whereas if all investors insure their portfolios synthetically, there is insufficient information for investors to estimate the aggregate

demand for insurance. Because investors cannot determine the demand for insurance, expectations are not efficient and price discontinuities like those in the Gennotte and Leland model may develop.

Sunshine trading proposals are designed to reduce the informational problems associated with synthetic securities by requiring dynamic hedgers to disclose their demands for insurance. Although popular following the October 1987 crash, sunshine trading proponents seem to have faded from view, in large part because dynamic hedging strategies have fallen in popularity. The October 1987 crash brought the realisation that dynamic hedging strategies cannot work when everyone is trying to dynamically hedge. Subsequent to the October 1987 crash, it is reportedly much more common for investors to insure their portfolios by purchasing index-put options. Although in theory this type of insurance should not create the informational problems associated with dynamic hedging, in practice, insured investors are apparently purchasing individualised over-the-counter index options, not exchange-traded options[5]. Because data on these options prices and open interest are not public, the information problem associated with portfolio insurance may still exist, especially if the over-the-counter index options writers are hedging their positions dynamically.

D. Transactions tax

In contrast to proposals designed to accommodate trading volume and attenuate its potential effects on volatility, there are alternative proposals designed to increase the cost of financial transactions in the hope of reducing speculative trading volumes. These proposals are essentially of two types: direct transactions taxes on financial transactions and increased minimum margin requirements on leveraged transactions.

Direct taxation of financial transactions has been proposed to increase the cost of short-term speculation and encourage longer average holding periods among investors (Tobin, 1984; Summers and Summers, 1989). Proponents of transactions taxes argue that the volumes of financial transactions in modern markets are not justified by informational or real investment considerations:

> "What is clear is that very little of the work of the securities industry, as gauged by the volume of market activity, has to do with the financing of real investment in any direct way".
>
> (Tobin, 1984)

Proponents argue that a small transactions tax will not significantly affect long-term investors, while it will discourage short-term "noise-trader" speculators from trading. Reducing "noise-trader" generated volatility may reduce the cost of capital to firms, thereby offsetting any negative impacts that the transaction tax might have on the supply of long-term investment capital. The proponents of such a tax argue that the alleged perverse impacts on liquidity have not been empirically documented.

Although these arguments are appealing, the practical experience with transaction taxes has not been very encouraging. Many major industrialised countries have some form of securities transactions tax, and these international differences provide some basis for the analysis of transactions tax effects. As Roll (1989) documents, during the October 1987 crash, stock prices fell in countries with transactions taxes as much or

more than stock prices in countries without them. In further analysis of the volatility-transactions tax relationship, Roll concludes:

> "Transactions taxes are inversely but insignificantly correlated with volatility across countries, and the effect is too questionable for taxes to be used with confidence as an effective policy instrument".
>
> (Roll, p. 143)

When a transactions tax is imposed or increased, share prices fall by an amount that reflects the present value of all expected taxes paid on the marginal share. The higher is share turnover, the larger the present value of the expected tax payments and the greater the drop in share prices.

Although proponents of a transfer tax argue that its effects on stock market prices, volume, and liquidity would be minor, the claim is not supported by the results of three recent studies. A study by the U.S. Congressional Research Service (Kiefer, 1987) estimates that the imposition of a 0.5 per cent transaction tax on stock sales would cause a 9.3 per cent reduction in the market value of stocks. In addition, the study suggests that the tax would be associated with reduced trading volume and an increase in market volatility due to reduced liquidity. Amihud and Mendelson (1990) predict more substantial effects on prices and trading volumes. Their findings suggest that the tax will have the largest price effects on the most liquid stocks and estimate that a 0.5 per cent transactions tax would reduce the price of an average Dow Jones Industrial index stock by 18 per cent, and the average NYSE listed stock by 13.8 per cent. White, Kupiec, and Duffee (1990) predict smaller effects and estimate that a 0.5 per cent tax would reduce share prices by less than 5 per cent[6].

Further evidence from international experience suggests that unilaterally increasing a transaction tax can have undesirable outcomes. The recent experience of Sweden is illustrative. In 1984, Sweden imposed a transaction tax and increased it significantly in 1988. Subsequently, domestic market volume, particularly on financial futures, declined drastically. Securities market transactions migrated to foreign markets effectively destroying the domestic Swedish futures market[7]. If international experience is any guide, nations seem to be reducing not increasing such transaction taxes[8].

E. Margin requirements

Following the October 1987 crash, there have been proposals to increase margin requirements, thereby reducing leverage in financial instruments. Increased margins are alleged to reduce volatility by restricting the behaviour of destabilising speculators. Although the importance of margin requirements on both stocks and stock index futures is under debate, for these instruments the required margin takes alternative forms and the required margin levels are set by different authorities.

Initial required margins on stocks are set by the Federal Reserve Board. The margin requirement determines the maximum legal amount that may be lent by a broker-dealer or a bank to an investor to enable him to purchase a marginable security. For example, an initial margin requirement of ***60*** per cent prohibits a broker-dealer or a bank from lending in excess of 40 per cent of the security's value. The Federal Reserve

Board has changed initial margin requirements 23 times since their introduction in 1934. The current initial margin rate is 50 per cent and has not been altered since 1974.

Initial margin in the future markets takes the form of a security deposit or performance bond. It is a fixed dollar amount per contract that, at the customer level, may be satisfied by depositing cash, treasury securities, securities listed on the AMEX or **NYSE** valued at 70 per cent of their market values, or an acceptable bank letter of credit with the Futures Commission Merchant. The dollar amount of the margin depends on the underlying contract, the type of trader posting margin, and the economic conditions prevailing at the time. Initial margins are set by the futures exchange's margin committee with the intent of ensuring the performance of a futures position. Given an estimate of the recent and expected volatility in the underlying futures contract price, the margin committee of the futures exchange sets initial margin deposits at levels that, with a high degree of confidence, exceed a large single-day's price change of a contract, but not so large as to limit market participation.

In the margin-volatility debate, the central issue is the claim that the amount of leverage available to investors has an influence on the volatility of financial asset prices. Those advocating such a relationship argue that significant leverage enables speculators to bid-up asset prices in excess of their fundamental equilibrium values and conversely, high leverage causes asset prices to fall more precipitously during market declines as leveraged investors are required to sell their stocks in order to meet margin calls. Following the stock market crash and depression of the 1930s, margin regulation was initially established by the **U.S.** Congress to stop this so-called pyramiding and depyramiding process.

Kupiec and Sharpe (1991) investigate the effects of leverage and margin requirements on stock price volatility in the context of an equilibrium model of asset price determination. Their results indicate that margin requirements can indeed lower volatility by restricting the demands of investors when equity prices are rising, but they can equally well increase volatility by restricting investors ability to purchase securities when equity prices are falling. Indeed, the latter effect of margins has been highlighted by the behaviour of the Japanese Ministry of Finance (MOF). During the fall of the Japanese equity market, the MOF lowered the margin requirements on equity purchases to encourage demand. Although the theoretical results of the Kupiec-Sharpe model suggest that active margin policies can reduce volatility, it is difficult, if not impossible, to determine ***ex ante*** whether stock prices are increasing for fundamental or speculative reasons. Without the ability to distinguish between fundamental and speculative price movements, an active margin policy may hinder efficient price adjustment.

The empirical literature investigating the effects of margin requirements on financial asset volatility is largely focused on the effects of the Federal Reserve Board's initial margin requirement on stock price volatility. Until recently, it was accepted that no relationship of any consequence, economic or statistical, exists between initial margin requirements and stock market price volatility. Recent papers by Hardouvelis (1988, 1990) disputed this conclusion and thereby rekindled interest in this area. Since the Hardouvelis studies, Schwert (1989), Kupiec (1989), Hseih and Miller (1990), and Salanger (1989) have empirically investigated the hypothesis that initial margin requirements and stock price volatility are inversely related. Without exception, they find no empirical evidence of an exploitable margin-volatility relationship.

The United States is not unique in its regulation of the initial margin required to purchase stocks. Roll (1989) investigates the international relationship between margin requirements and stock price volatility. He concludes:

> "For the pre-cash and post-crash periods, [the estimates] contain absolutely no evidence that margin requirements have an influence on volatility, regardless of whether returns are measured in local currency or in dollars and regardless of the length of the holding interval".
>
> (Roll, p. **140)**

Unlike an investment in a common stock which generates positive cash flow only at the time of sale (or dividend payment), an index futures contract generates cash flow daily as the open futures positions are marked to market. The daily mark-to-market and corresponding payment of variation margin (the one-day gains or loss on the contract) on futures contracts resets the value of a futures position to zero at market open each day. As such, a futures margin payment is a performance bond for a one-day futures position, and adequate margin must be posted again the following day.

From a prudential standpoint, the performance bond necessary to establish a futures position need only be large enough to protect against probable one-day movements in a contract's value[9]. Margin on the S&P 500 stock-index futures contract has averaged around **4** per cent for institutional investors who are generally classified as hedgers (Kupiec, **1990).** The lower level of margin creates a substantial leverage advantage in favour of stock-index futures. For an equivalent move in the cash and futures index, an **S&P** 500 index-futures position yields about twelve times the return of the maximally leveraged cash position.

The degree of leverage available in index-futures products relative to cash markets is often cited as *prima facie* evidence that futures markets are the conduit of speculation and excess volatility. Although this view is common to those advocating "equalised" margins, there is little statistical evidence to supports the view that a low margin causes high volatility.

Fishe, Goldberg, Gosnell and Senha **(1990)** study the effects of margin changes on the futures prices of 10 real commodities. They find no systematic margin-volatility relationship. Instead, margin-volatility effects are mixed across time and contract – sometimes positive, sometimes negative. The results do not suggest a stable policy-exploitable relationship. Kupiec (1990) investigates the proposition that the level of cash market volatility is related to the degree of leverage in stock index-futures contracts. The only evidence of a statistically significant relationship suggests that high margin rates in the futures markets tend to be associated with periods of above average volatility in the cash markets. The results show no evidence that an exploitable relationship exists between the level of stock-index futures margins and cash market volatility.

IV. SUMMARY

Over the past thirty years, stock return volatility appears to have increased in many OECD countries. No attempt is made to isolate the economic causes of the increased

volatility but, statistically, the higher average volatility recorded in the 1980s was caused by short periods of abnormally high return volatility. These periods were transitory and volatility quickly reverted toward lower, more "normal" levels. Nevertheless, these transitory periods raised measures of average volatility for the decade. Accompanying this general increase in the level of financial asset price volatility is a general increase in the strength of the positive correlations among stock index returns and the conditional volatilities of these returns across OECD countries. The statistical evidence indicates that nation's stock markets are more likely to record above-(below-) average returns simultaneously, and exhibit above- (below-) average return volatility concurrently.

Although the average levels of volatility appear to be higher in financial markets in the late 1980s, there is no strong evidence that the increase in volatility has had negative effects on economic activity. The world-wide stock market crash of 1987 did not significantly impact economic activity, nor have the October 1989 stock market "mini-crash" or the fall in the value of Japanese stocks and other Far Eastern equity markets had strong domestic real economic impacts.

Although recent episodes of "excess" volatility have not had substantial real economic effects, regulatory reform and reform proposals designed to limit "excess" volatility have proceeded apace. The evidence from the October 1989 mini-crash in the United States indicates that reforms designed to enhance the integrity of the financial infrastructure, that is, trading capacity additions and clearing and settlement reforms, performed satisfactorily. However, the experience with "circuit breaker" temporary price limits suggests that the existing series of coordinated price limits may benefit from reforms that better address the timing of co-ordinated price limits. On balance, there is no strong empirical or theoretical evidence that suggests that transactions taxes, circuit breakers, or margin requirements are policy tools that can be used to control equity price volatility. Continuing research is needed to enhance our understanding of these tools and their potential usefulness in an efficient financial regulatory system.

NOTES

1. Theory predicts that floating exchange rates insulate the domestic economy from foreign shocks. However, the theoretical insulation property depends on strict assumptions not satisfied in practice (Dornbusch, 1983). Consequently the degree of insulation provided by floating exchange rates is an empirical issue.
2. For a summary of the U.S. market changes see U.S. SEC (1989). For international proposals see, FIBV (1989), or, Group of Thirty (1989).
3. This is true for the primary quote on the ESP. Secondary quotes are also posted and are calculated from ESP-required quotes from the individual stock specialists. If a large ESP order were placed, it could involve directly sending individual orders to specialist posts.
4. A simple put option is a security that gives the purchaser the right, but not the obligation, to sell a predetermined number of shares of an underlying security at a predetermined price by a predetermined date.
5. For a discussion of this point, see Duffee, Kupiec and White (1990). An over-the-counter option is a customised option contract written between two parties. It is not standardised, cannot be easily traded in a secondary market, and activity in these options is not publicly reported.
6. The differences in the estimated tax effects on share prices owe to different assumptions about the "normal" level of share turnover and the elasticity of turnover with respect to trading costs. White, Kupiec, and Duffee use the average NYSE 1989 turnover rate as the "normal" turnover level from which to calculate the tax's effects. They consider different trading-cost-turnover elasticities and estimate a range of probable price effects. Kiefer bases his estimates on the 1987 NYSE average turnover rate. This rate is 50 per cent higher than the 1989 rate used by White, Kupiec, and Duffee and largely accounts for the differences in the tax's estimated price impact. Amihud and Mendelson base their estimates on an empirical analysis of the relationships between required returns and bid-asked spreads. Bid-asked spreads are empirically and theoretically related to turnover rates. Although a turnover rate assumption is implicit in their approach, it is not an explicit assumption that can be compared to those used in the other studies.
7. The Stockholm Stock Exchange estimates that about 1/3 of the Swedish companies' share volume was driven offshore. See Moore (1989).
8. Evidence from other financial markets does not support the efficacy of transactions taxes in promoting market efficiency. Real estate transactions are among the highest cost asset transactions, yet the evidence on the efficiency of real estate markets does not suggest that they are immune from volatility, "fad" expectations, or fundamental mispricing. Indeed the findings of recent papers by Cutler, Poterba and Summers (1989) and Shiller (1990), as well as recent historical experiences in the United States, United Kingdom and Japan do not suggest that real estate markets are any more immune to "fads" than are stock markets.
9. In fact, margins are calculated and collected multiple times a trading day, so in practice, the margin need not cover a full day's potential price move.

Technical appendix

A. Schwert volatility estimator

The Schwert volatility estimator is calculated by first regressing monthly returns on monthly dummy variables and 12 lagged return values. The absolute values of the estimated residuals from this regression are then regressed on monthly dummy variables and 12 lagged values of the transformed residuals. The predicted values from the second regression, scaled by a constant (1.2533 under the assumption of monthly returns normality), are estimates of the standard deviation of monthly returns.

STEP 1: Estimates e_t from the model,

$$R_t = \sum_{i=1}^{12} \alpha_i D_i + \sum_{i=1}^{12} \beta_i R_{t-1} + \tilde{e}_t$$

where D_i is a dummy variable that takes the value of 1 if R_t occurs during the month, and 0 otherwise.

STEP 2: Estimate the predicted values from the model,

$$|\hat{e}_t| = \sum_{i-1}^{12} \Upsilon_i D_i + \sum_{i=1}^{12} \delta_i |\hat{e}_{t-1}| + \tilde{v}_t$$

The rescaled predicted values from this model, $1.2533\ |\hat{e}_t|$, are estimates of the monthly return standard deviations under the assumption that monthly returns are normally distributed.

B. Stock price data

For the analysis of trends over the entire 30 years, monthly data from the OECD data base were used. The composition of the OECD stock price indices differ by country. For the United States, Belgium, Finland, France, Germany, Norway, and the United Kingdom, the indices are calculated using only industrial share prices. For the remaining markets, the indices are calculated using all listed shares. The Belgium stock index is calculated using closing prices from the end of the month. The stock indices for Canada, Finland, Japan, the Netherlands, Spain, Sweden, and the United Kingdom are calculated from closing prices on the last trading day of the month. The French and Swiss stock indices are calculated from closing prices on the last Friday of the month. The stock indices for Germany and the United States are averages of monthly prices. Ireland and Norway's indices are calculated from closing prices at the beginning of the month, and to correct for this timing difference we lag these countries returns and volatilities one month. The analysis was restricted to those markets for which the OECD financial data base included data from 1960.

Table A.1. Estimated monthly stock index return correlations for selected sample periods

Fixed and floating exchange rate periods

	U.S.	U.K.	JAP	FRA	GER	CAN	ITA	BEL	FIN	IRE	NET	NOR	SPA	SWE	SWI
United States	–	0.45*	0.19*	0.28*	0.39*	0.59'	0.21*	0.47'	0.04	0.09	0.46*	–0.09	0.05	0.24'	0.41*
United Kingdom	0.53*	–	0.21*	0.22*	0.24*	0.36*	0.11	0.33'	0.14	0.09	0.42*	0.04	0.10	0.18*	0.38*
Japan	0.40'	0.37*	–	0.15	-0.02	0.14	0.24*	0.17	0.20*	0.07	0.17*	0.00	0.20*	0.21*	0.12
France	0.38*	0.24*	0.36*	–	0.31"	0.23*	0.30'	0.54'	0.24*	-0.02	0.31*	0.00	0.36*	0.10	0.44*
Germany	0.42*	0.39*	0.31*	0.32*	–	0.39*	0.13	0.28'	0.05	0.10	0.45*	0.17	0.11	0.19*	0.50'
Canada	0.60*	0.33*	0.21*	0.45'	0.19*	–	0.14	0.30*	0.13	0.11	0.57*	-0.17	0.06	0.29'	0.49*
Italy	0.31*	0.32*	0.28*	0.19*	0.33'	0.22*	–	0.22*	-0.03	–0.01	0.08	0.07	0.10	-0.02	0.30*
Belgium	0.45*	0.35	0.24*	0.53*	0.41'	0.36*	0.25*	–	0.10	0.07	0.43*	0.03	0.24*	0.28*	0.44'
Finland	0.11	0.09	0.17	0.13	0.20'	0.09	0.18*	0.26*	–	0.02	0.03	0.26*	0.21*	0.16	-0.04
Ireland	0.05	0.02	0.16	–0.01	0.06	-0.07	0.03	0.00	0.14	–	0.09	0.25*	0.10	0.08	0.10
Netherlands	0.53'	0.41*	0.21*	0.44*	0.47*	0.56*	0.26*	0.50*	0.23*	-0.05	–	0.02	0.03	0.31'	0.67*
Norway	-0.13	–0.21*	0.03	-0.02	0.02	-0.25'	-0.07	-0.05	0.20*	0.45*	-0.17	–	0.19*	-0.11	-0.25'
Spain	0.32*	0.23*	0.24*	0.29*	0.26*	0.27*	0.27*	0.32*	0.20*	-0.02	0.34*	0.30'	–	0.24'	0.16
Sweden	0.33'	0.27*	0.19*	0.24*	0.24*	0.35*	0.20*	0.23*	0.24*	-0.07	0.44*	-0.10	0.30'	–	0.27*
Switzerland	0.52*	0.36*	0.18*	0.46*	0.49*	0.56*	0.23*	0.50'	0.14	-0.02	0.70'	-0.01	0.28*	0.44*	–

* Indicates that the correlation estimate is significantly different from zero at the 5 per cent level.

Note: The estimated monthly index return correlations for the faixed exchange rate period (January 1961/December 1970) appear above the main diagonal. Below the main diagonal are the estimated monthly index return correlations for the floating exchange rate period (January 1974/December 1989).

Table A.2. Estimated monthly stock index return correlations for selected sample periods

1980-84, 1985-89

	US.	U.K.	JAP	FRA	GER	CAN	ITA	BEL	FIN	IRE	NET	NOR	SPA	SWE	SWI
United States	–	0.51'	0.37'	0.35*	0.47'	0.67'	0.21	0.28	-0.14	0.00	0.46'	0.33*	0.09	0.18	0.53*
United Kingdom	0.59*	–	0.50*	0.24	0.36*	0.46'	0.35*	0.31*	–0.10	–0.10	0.44'	0.34*	-0.03	0.08	0.36*
Japan	0.42'	0.33'	–	0.38*	0.37*	0.31*	0.18	0.26'	0.09	0.18	0.36'	0.39*	0.27'	0.16	0.38*
France	0.44'	0.31*	0.32*	–	0.21	0.24	0.02	0.43*	0.02	-0.08	0.30*	0.38"	0.07	0.05	0.36*
Germany	0.45*	0.43"	0.29*	0.49'	–	0.37*	0.13	0.31*	0.21	0.08	0.48'	0.25'	0.24	0.15	0.48*
Canada	0.67'	0.43'	0.22	0.59*	0.23	–	0.31'	0.19	-0.06	-0.08	0.47'	0.24	0.01	0.30	0.63*
Italy	0.31'	0.35'	0.28*	0.23	0.45'	0.22	–	0.16	0.07	-0.04	0.30*	0.17	0.17	0.16	0.12
Belgium	0.57'	0.40*	0.25	0.62*	0.46*	0.48"	0.24	–	0.21	-0.10	0.39'	0.18	-0.16	–0.09	0.38*
Finland	0.19	0.35*	0.27'	0.11	0.28	0.03	0.24	0.23	–	0.12	0.28*	0.13	0.10	0.14	0.07
Ireland	-0.01	-0.14	0.15	0.07	0.12	-0.13	0.12	0.08	0.26'	–	0.04	–0.09	0.05	0.08	–0.10
Netherlands	0.67'	0.52'	0.26'	0.54'	0.48*	0.75'	0.33"	0.53*	0.10	-0.12	–	0.14	0.13	0.24'	0.59'
Norway	0.48"	0.50*	0.26'	0.13	0.57'	0.08	0.20	0.21	0.38*	0.09	0.26'	–	0.13	0.23'	0.20
Spain	0.49*	0.43*	0.25	0.47'	0.26'	0.58"	0.38*	0.52*	0.20	0.00	0.49*	0.02	–	0.06	-0.01
Sweden	0.52'	0.46'	0.19	0.44'	0.34'	0.45'	0.27'	0.39'	0.27'	-0.14	0.65'	0.26*	0.40'	–	0.31'
Switzerland	0.53*	0.37'	0.10	0.59'	0.54'	0.67'	0.32'	0.53'	0.06	0.00	0.80*	0.19	0.46'	0.55*	–

• Indicates that the correlation estimate is significantly different from zero at the 5 per cent level.

Note: The estimated monthly index return correlations for the period (January 1980/December 1984) appear above the main diagonal. The correlation estimates for the period (January 1985/December 1989) appear below the diagonal.

For a more limited period and sample of countries, daily data from the Bank for International Settlements data base was used. The stock indices are commonly reported in the financial press. They are: the S&P 500 for the United States, the TOPIX for Japan, the Commerzbank index for Germany, the CAC index for France, the FT100 index for the United Kingdom, the Sydney all-ordinary share index for Australia, the Stockholm stock index for Sweden, and the TSE 300 for Canada.

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