Asset price volatility and monetary policy in Switzerland

Andreas M. Fischer[1]

Introduction

Volatility is a key variable that permeates most financial instruments and plays a decisive role in many areas of finance and monetary policy. The widespread existence of volatility and its persistence have led researchers to consider its origins. One source of volatility is the introduction of new financial instruments and investment strategies. These measures, depending on their structure, can heighten market volatility by altering the price dynamics. Another source of price volatility is market reaction to news. Improved networks in communication allow markets to respond quickly to new information. The constant re-evaluation of expectations based on increasing volumes of information gives the impression that markets are myopic. Shortsightedness can lead to deviations from fundamentals and to sharp movements in asset prices. These so-called price misalignments or bubbles appear perplexing in that it is often difficult to justify the market's behaviour.

The objective of this paper is to present an overview of the role of news, financial products and price misalignments within the context of Swiss financial markets. I begin by presenting the main stylised facts of Swiss financial markets. Attention focuses on the stock, bond, foreign exchange (FOREX) and real estate market. Measures of volatility are defined and the main properties of the volatility estimates within the GARCH framework are discussed. Next, the discussion addresses the role of news stemming from the Swiss National Bank (SNB), i.e. giro and intervention announcements, on exchange rate volatility. Thereafter, the argument whether new investment strategies and the emergence of new financial instruments are responsible for the observed increase in volatility is addressed. The last section discusses several episodes of price misalignments in various financial markets and their consequences for SNB monetary policy.

1. Stylised facts of financial market volatility

1.1 Measures of financial market volatility

The presentation of the stylised facts for volatility is based on two measurement concepts. The first uses the traditional measure of volatility (the amplitude of price swings) - the standard deviations of return. Below, normalised standard deviations are reported; the standard deviation of one-week, four-week, twelve-week changes are divided by the square roots of five, twenty, and sixty respectively. The normalised standard deviations are equal across the different frequencies in large samples if the asset prices follow a random walk. One question of interest is to determine whether asset price volatility has increased in the 1990s. The statistical measures compare the subsamples 1980-89 versus 1990-95.

The second measurement concept attempts to model volatility. The generalised autoregressive conditional heteroskedastic (GARCH) model by Bollerslev (1986) offers a good proxy

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for non-linear processes.[2] GARCH is a class of ARCH (AutoRegressive Conditional Heteroskedasticity) models, which rest on the presumption that forecasts of the variance at some future point in time can be improved by using recent information. In particular, volatility clustering implies that big surprises of either sign will increase the probability of future volatility. Forecasts of volatility that recognise this feature will generally be more accurate than those that do not.

The GARCH (p,q) process in its most general form is specified as follows:

$$x_t = \beta_0 + \beta_1 x_{t-1} + \ldots + \beta_k x_{t-k} + \gamma z_t + e_t, \qquad e_t \sim \text{student-t distribution} \qquad (1)$$

$$VAR(e_t) = h_t = \alpha_0 + a_{1,1}\, e_{t-1}^2 + \ldots + \alpha_{1,q}\, e_{t-q}^2 + \alpha_{2,1}\, h_{t-1} + \ldots \alpha_{2,p}\, h_{t-p} \;\; + \alpha_3 y_{t-1}.$$

The variable of interest, x_t is defined to be an I(0) stationary process. The error term is assumed to follow a student-t distribution. The conditional mean includes an autoregressive process of order k plus the variable z_t that allows for regime shifts, volatility and other information. The variable y_{t-1} denotes other information and may influence the volatility of x_t. Section 2, which considers the role of SNB information on the volatility in the FOREX market, replaces y_{t-1} with the change in giro positions and SNB interventions.

An appealing feature of the GARCH (p, q) model concerns the time series dependence in e_t^2. The above equation is readily interpreted as an ARMA model for e_t^2 with autoregressive parameters $\alpha_1(L)+\alpha_2(L)$, moving average parameters $\alpha_2(L)$, and the serially uncorrelated innovation sequence $v_t = (e_t^2 - h_t)$. The expression for the conditional variance in equation (1) with $\alpha_3 = 0$ can be rewritten as:

$$e_t^2 = \alpha_0 + \left(\alpha_{1,1} + \alpha_{2,1}\right)e_{t-1}^2 + \ldots + \left(\alpha_{1,m} + \alpha_{2,m}\right)e_{t-m}^2 - \alpha_{2,1}v_{t-1} - \ldots - \alpha_{2,p}v_{t-p} + v_t$$

where $m = \max(p, q)$. The ARMA (m, p) representation aids identification of the order's p and q, though in most applications $p = q = 1$ suffices.

One variant of the GARCH model allows the volatility measure defined by the square root of the conditional variance $\sqrt{h_t}$ to enter the conditional mean. Market risk or volatility captured by the conditional variance $\sqrt{h_t}$ has a direct influence on asset prices. Such a model is called GARCH in mean or GARCH-M. An alternative variant of the GARCH model considers whether the conditional variance is an integrated process. The restriction $\alpha_{2,1} = (1-\alpha_{1,1})$ for the GARCH (1,1) model implies that the conditional variance is non stationary. The test for I-GARCH (1,1) imposes the restriction $\alpha_{2,1} = (1-\alpha_{1,1})$ and compares the likelihood values with the GARCH (1,1) specification. The integrated GARCH or I-GARCH is a departure from the GARCH model with mean reversion in the conditional variance.

The periodicity of the financial assets (stocks-weekly, bonds-daily, FOREX-daily, real estate-monthly) for the GARCH estimates is motivated by the observation that most studies for

2 As noted in Goodhart and O'Hara (1995), there are alternative ways of modelling (non-linear) time-varying volatility; two approaches merit brief mentioning. The first is to model the variance as an unobserved stochastic process (Harvey et al. (1994)). Stochastic variance models tie in closely with developments in finance theory and have certain econometric advantages compared with GARCH. They allow an error term to enter the volatility equation and are more flexible and more complicated in application with multi-variate models than GARCH models. The other alternative is to use the implicit forecast of volatility derived from the option market to forecast subsequent volatility in the spot market. Such option forecasts have compared well with a GARCH estimate as a predictor of future volatility (see Harvey and Whaley (1992)).

Switzerland consider only monthly or quarterly data. A higher order frequency also ensures the success of the GARCH estimates below.[3]

1.2 Stock prices

Figure 1 plots the level and the weekly change of the Credit Suisse index. The level of the stock index has an upward trend marked by sharp falls in 1987, 1990 and 1994. The October 1987 Crash is visible in the weekly change of the stock index. Except for this one-time outlier, the change in the weekly data suggests that volatility has not changed considerably over the last ten years. Hence, the GARCH estimates should not be sample dependent.

Figure 1

Weekly stock index, 1980-95

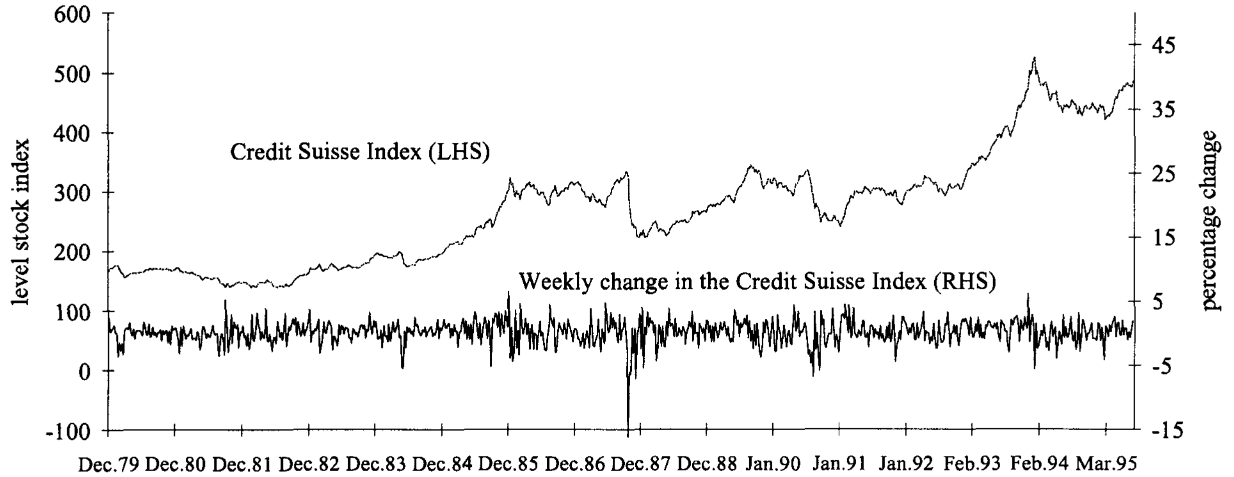


Table 1 presents the normalised standard deviations for the stock index, the bond yields, the FOREX returns and the property index. Standard deviations are given for the subperiods (1980-89), (1990-95) and the sample (1980-95). The volatility measure highlights two features. First, despite the 1987 Crash, the level of volatility in the 1980s is similar to that of the 1990s.[4] Second, the volatilities as measured by the normalised standard deviations are close in value, so that the pattern of volatility across the time aggregation for each subsample suggests a random walk behaviour. This result is also true for the bond, FOREX, and property markets.

The GARCH (1,1) specification captures well the weekly movements in the stock index, a finding consistent with the GARCH estimates of Grünbichler and Schwartz (1993) for the period 1989-92. Table 2 presents the empirical estimates for three sample periods. Only the lagged dependent variable is introduced as an independent variable in the conditional mean. The results show that the conditional variance under the GARCH (1,1) specification is robust across the 1980s and 1990s. Below, alternative specifications for the conditional mean and variance are considered.

3 For an overview of microstructure (intra-daily) volatility, see Goodhart and O'Mara (1995). Numerous studies consider intra-daily volatility for the Swiss franc, see Goodhart and Demos (1993), Müller *et al.* (1995), Wasserfallen (1989) and Wasserfallen and Zimmermann (1985).

4 For a cross comparative study using the standard deviation as a measure of volatility see Odier, Solnik and Zucchinetti (1995). They find that the Swiss stock market is the least volatile among the G-10 countries.

Table 1

Volatility of asset prices, 1980-95

	Normalised standard deviation of the change in asset prices		
	1980-95	**1980-89**	**1990-95**
Stock index			
Weekly	1.96	1.99	1.93
Monthly	2.16	2.19	2.00
Quarterly	2.36	2.35	2.38
Bonds			
Daily	0.026	0.018	0.036
Weekly	0.030	0.025	0.038
Monthly	0.038	0.013	0.046
Quarterly	0.037	0.016	0.031
Nominal exchange rates			
Daily			
Yen	0.620	0.536	0.7457
Deutsche Mark	0.286	0.272	0.308
Dollar	0.829	0.820	0.846
Weekly			
Yen	0.566	0.509	0.658
Deutsche Mark	0.257	0.255	0.261
Dollar	0.733	0.737	0.728
Monthly			
Yen	0.645	0.582	0.743
Deutsche Mark	0.287	0.293	0.277
Dollar	0.828	0.844	0.796
Quarterly			
Yen	0.665	0.584	0.665
Deutsche Mark	0.309	0.319	0.309
Dollar	0.879	0.889	0.861

Property (1992-95)	**Rental units**	**Apartments**	**Family homes**	**Office buildings**
Monthly	0.42	0.65	0.49	1.09
Quarterly	0.59	0.81	0.56	1.42

Table 2

GARCH (1, 1) model for financial variables

Model: $\Delta x_t = \beta_0 + \beta_1 \Delta x_{t-1} + e_t$, $h_t = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1}$

Variables	Bonds	Stocks	Exchange rates		
			Yen	Deutsche Mark	Dollar
1980-95					
β_0	- 2.160	0.176*	0.028*	0.001	0.003
	(- 0.787)	(2.904)	(3.716)	(0.303)	(0.227)
β_1	0.119*	0.127*	0.029	0.014	- 0.027
	(7.283)	(3.017)	(1.785)	(0.779)	(- 1.586)
α_0	9.411*	0.305*	0.026*	0.005*	0.019*
	(16.878)	(4.318)	(29.362)	(15.436)	(7.021)
α_1	0.138*	0.170*	0.154*	0.121*	0.080*
	(22.201)	(5.885)	(13.667)	(15.588)	(9.980)
α_2	0.858*	0.760*	0.785*	0.829*	0.895*
	(187.965)	(19.416)	(85.239)	(101.152)	(95.210)
Likelihood value	**13,103.1**	**849.1**	**225.9**	**3,200.3**	**1,041.7**
1980-89					
β_0	- 8.561	0.216*	0.029*	0.002	0.019
	(- 0.288)	(3.027)	(3.144)	(0.402)	(1.314)
β_1	0.188*	0.085	0.055*	0.022	- 0.015
	(8.538)	(1.422)	(2.347)	(0.977)	(- 0.705)
α_0	1.837*	0.465*	0.032*	0.005*	0.021*
	(12.551)	(3.778)	(23.591)	(13.824)	(5.414)
α_1	0.164*	0.326*	0.185*	0.139*	0.096*
	(17.397)	(7.928)	(10.522)	(11.781)	(8.044)
α_2	0.790*	0.615*	0.710*	0.802*	0.876*
	(79.581)	(10.222)	(48.137)	(71.073)	(61.181)
Likelihood value	**9,103.5**	**550.2**	**494.29**	**2,178.7**	**602.8**
1990-95					
β_0	- 0.001	0.172	0.010	- 0.002	- 0.039
	(- 1.374)	(1.625)	(0.604)	(- 0.298)	(- 1.783)
β_1	- 0.018	0.152*	- 0.019	- 0.014	- 0.063*
	(- 0.579)	(2.161)	(- 0.677)	(- 0.444)	(- 2.211)
α_0	0.000*	0.807*	0.064*	0.025*	0.088*
	(8.981)	(2.836)	(7.472)	(10.302)	(13.500)
α_1	0.131*	0.143*	0.117*	0.149*	0.087*
	(7.448)	(2.210)	(7.351)	(8.681)	(4.654)
α_2	0.783*	0.611*	0.772*	0.590*	0.793*
	(36.614)	(5.229)	(33.346)	(17.076)	(38.770)
Likelihood value	**4,031.3**	**298.9**	**440.4**	**940.9**	**443.4**

Note: Terms in parentheses are *t* values and * denotes significance at the 5% level.

Table 3

GARCH-M (1,1) model for financial variables

Model: $\Delta x_t = \beta_0 + \beta_1 \Delta x_{t-1} + \beta_2 \sqrt{h_t} + e_t, \qquad h_t = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1}$

Variables	Bonds	Stocks	Exchange rates		
			Yen	Deutsche Mark	Dollar
1980-95					
β_0	9.747	0.359	0.087*	0.009	0.117
	(0.167)	(1.122)	(2.677)	(0.610)	(2.287)
β_1	0.120*	0.123*	0.023	0.013	- 0.030
	(7.320)	(2.922)	(1.389)	(0.735)	(- 1.743)
β_2	- 0.019	- 0.112	- 0.117	- 0.031	- 0.155*
	(- 0.544)	(- 0.588)	(- 1.916)	(- 0.538)	(- 2.270)
α_0	8.623*	0.304*	0.017*	0.005*	0.019*
	(15.876)	(4.239)	(23.267)	(14.125)	(6.807)
α_1	0.128*	0.161*	0.133*	0.120*	0.080*
	(22.383)	(5.678)	(13.948)	(15.401)	(9.985)
α_2	0.868*	0.765*	0.828*	0.830*	0.894*
	(204.789)	(19.377)	(100.896)	(95.283)	(93.817)
Likelihood value	**13,103.2**	**848.72**	**229.2**	**3,200.4**	**1,043.1**
1980-89					
β_0	5.508	0.301	0.126	0.021	0.216*
	(0.289)	(0.901)	(3.322)	(1.266)	(3.901)
β_1	0.433*	0.085	0.052*	0.020	- 0.024
	(8.454)	(1.425)	(2.271)	(0.898)	(- 1.119)
β_2	- 0.068	- 0.058	- 0.214*	- 0.080	- 0.277*
	(- 0.320)	(- 0.284)	(- 2.654)	(- 1.201)	(- 3.591)
α_0	1.759*	0.435*	0.027*	0.005*	0.021*
	(6.802)	(3.619)	(19.177)	(12.501)	(5.219)
α_1	0.217*	0.295*	0.171*	0.139*	0.097*
	(4.914)	(7.357)	(10.422)	(11.670)	(8.120)
α_2	0.633*	0.641*	0.739*	0.804*	0.874*
	(13.356)	(10.673)	(49.760)	(67.334)	(60.387)
Likelihood value	**2,075.6**	**549.7**	**498.4**	**2,179.2**	**616.9**
1990-95					
β_0	0.002	0.523	- 0.067	- 0.078	- 0.488*
	(0.464)	(0.616)	(- 0.879)	(- 1.525)	(- 5.688)
β_1	- 0.017	0.153*	- 0.020	- 0.009	- 0.063*
	(- 0.563)	(2.093)	(- 0.719)	(- 0.286)	(- 2.230)
β_2	- 0.103	- 0.203	0.113	0.263	0.564*
	(- 0.739)	(- 0.413)	(0.985)	(1.508)	(5.045)
α_0	0.000*	0.838*	0.062*	0.020*	0.056*
	(7.361)	(2.685)	(7.006)	(9.584)	(9.514)
α_1	0.128*	0.148*	0.116*	0.139*	0.076*
	(7.443)	(2.181)	(7.367)	(8.621)	(5.124)
α_2	0.790*	0.596*	0.777*	0.654*	0.848*
	(35.014)	(4.717)	(32.808)	(21.564)	(49.930)
Likelihood value	**4,031.6**	**298.9**	**440.6**	**947.8**	**1,006.5**

Note: Terms in parentheses are *t* values and * denotes significance at the 5% level.

An interesting property of market volatility relates to the persistence of shocks to the conditional variance. Several authors find evidence of a unit root for American stock indexes: French, Schwert and Stambaugh (1987), Chou (1988) and Pagan and Schwert (1990). The observation that $\alpha_1+\alpha_2$ is less than one in Table 2 for the Swiss stock index suggests that the I-GARCH specification should be rejected. The sum of the coefficient values is 0.93 for the whole sample period, 0.93 for the 1980s and 0.75 for the 1990s. An I-GARCH result implies that mean reversion of the conditional variance does not take place.

The estimates for the GARCH-M model are given in Table 3. The GARCH-M specification does not fit the data well for stock prices. The introduction of a volatility measure in the conditional mean does not alter the estimates of the conditional variance. The parameter coefficients of $\alpha_1+\alpha_2$ are consistent with mean reversion and are similar to those of the GARCH model presented in Table 2. The coefficient for the volatility measure β_2 in the conditional mean is not significant in any of the three sample periods. The small difference in the likelihood values between the GARCH and GARCH-M models confirms the finding that volatility does not directly influence stock prices.

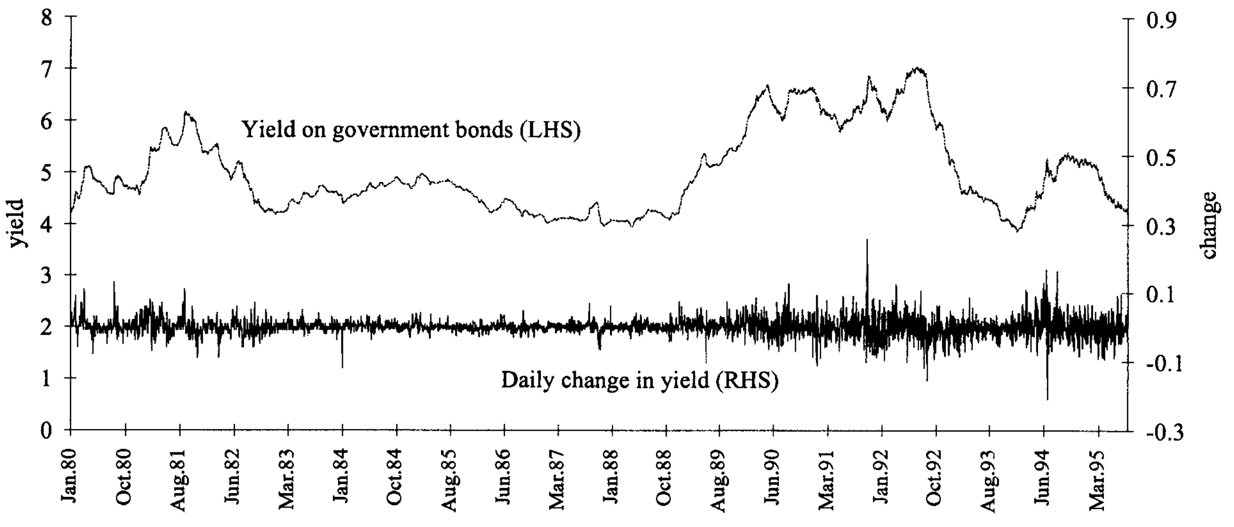
1.3 Government bonds

Figure 2 depicts the yield on Swiss government bonds and its daily change. Three humps characterise the evolution of the yield for the period 1980-95. The first two humps (1980-82 and 1989-93) are consistent with periods of high inflation; however, the last rise in the bond yield (1994) occurred during a period when inflation averaged less than 1%. Section 3 discusses this last episode in greater detail. The change in the daily yield suggests that volatility increased considerably during the 1990s. The volatility measures given in Table 1 confirm this conjecture. In some cases, the standard deviations of the 1990s are almost twice those of the 1980s.

The GARCH estimates in Tables 2 and 3 reveal that the volatility of government bonds is highly autocorrelated; however, volatility does not manifest itself in the conditional mean. The GARCH-M specification is rejected for all three sample periods. There is weak evidence of mean reversion for the subsample periods ($\alpha_1+\alpha_2$ = 0.95 for the 1980s and $\alpha_1+\alpha_2$ = 0.91 for the 1990s); however, the I-GARCH estimate of $\alpha_1+\alpha_2$ = 0.99 is not rejected for the whole sample. The difference in the log likelihood between the I-GARCH and the GARCH model is only 0.24.

Figure 2

Yield on Swiss government bonds



1.4 Exchange rates

The levels and the daily changes of the Japanese yen, the Deutsche Mark and the US dollar are given in Figures 3a-3c. The Deutsche Mark distinguishes itself from the other two exchange rates in that there is no trend. The yen appreciated whereas the dollar depreciated against the Swiss franc over the last fifteen years. With respect to the plots of the daily change in the exchange rates, the dollar and the Deutsche Mark do not exhibit visible signs that volatility increased during the last five years. The standard deviations in Table 1 show that the volatility in the yen increased during the 1990s, whereas for the dollar and the Deutsche Mark volatility appears to have remained nearly constant over the last ten years.

Figure 3a

Swiss franc/yen exchange rate

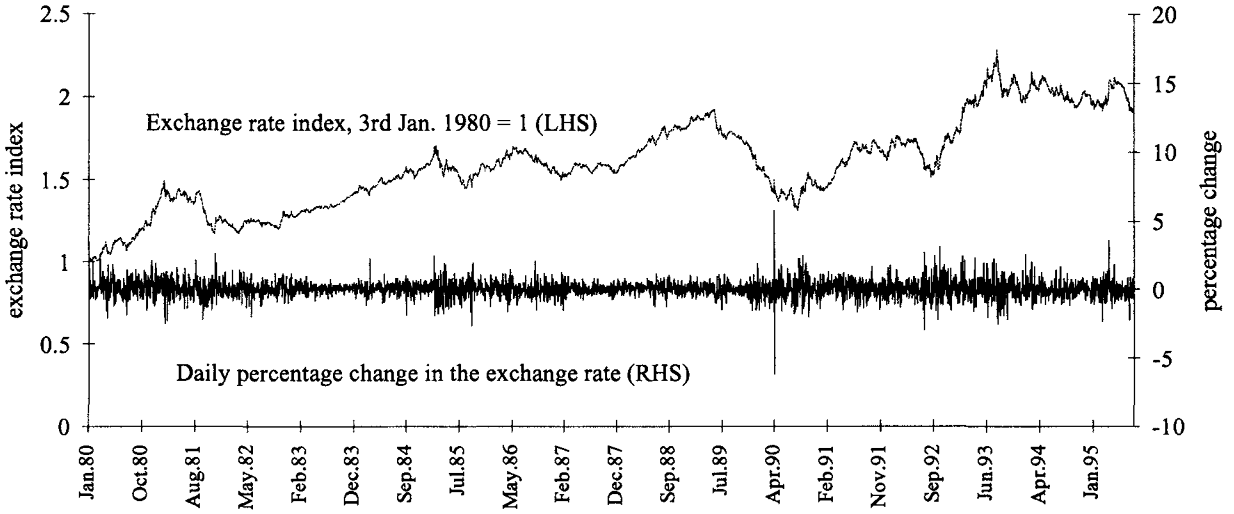


Figure 3b

Swiss franc/Deutsche Mark exchange rate

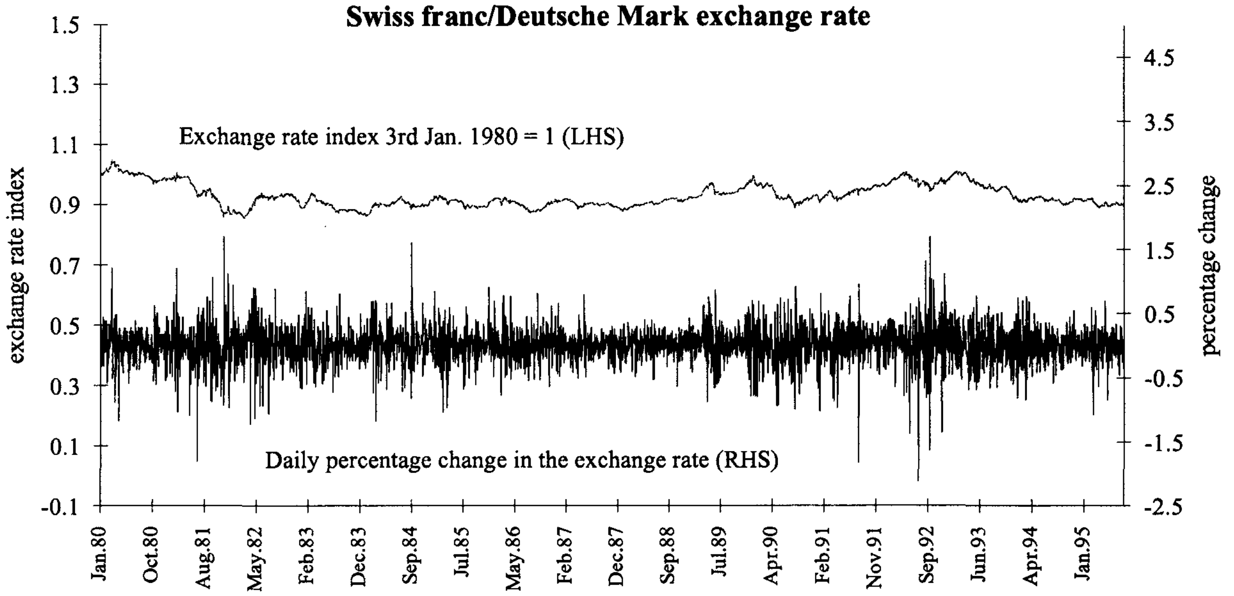
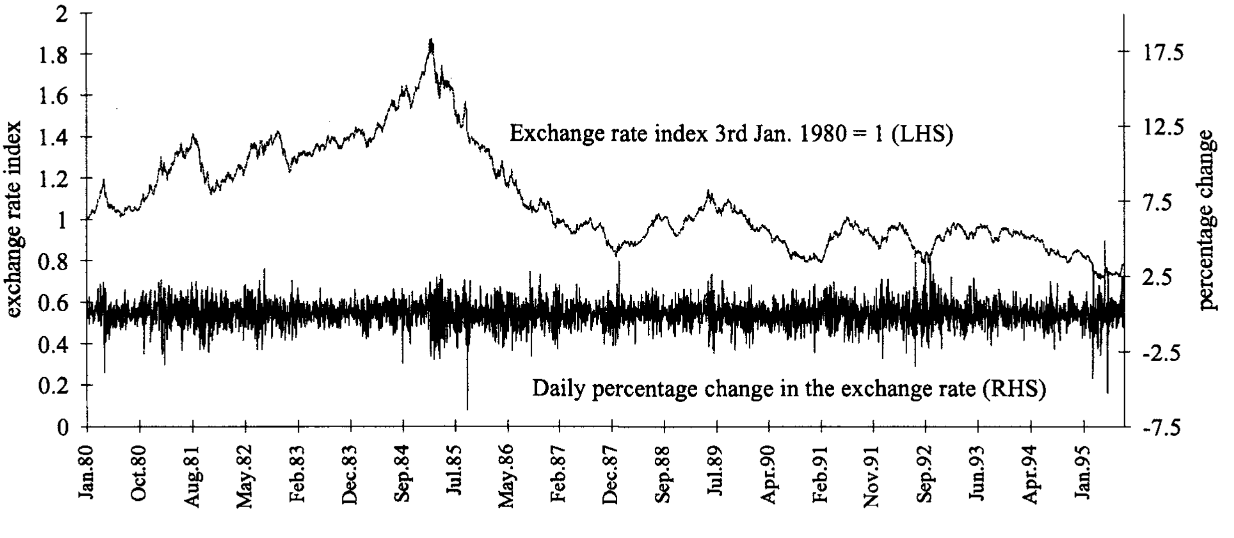


Figure 3c

Swiss franc/US dollar exchange rate



The GARCH estimates for the foreign exchange rates are given in Tables 2 and 3. Although the GARCH specification is found to be valid for the exchange rates, it becomes immediately apparent that they have different properties. One differentiating feature is that the I-GARCH representation is valid only for the dollar rate. As in Engle and Bollerslev (1986), the conditional variance for the dollar rate is found to be non-stationary. Evidence of mean reversion of volatility is stronger during the 1990s than during the 1980s, except for the yen, where there is virtually no difference. The least amount of persistence is for the Deutsche Mark/Swiss franc rate for the 1990s. During the 1990s the persistence of a volatility shock (in the conditional variance) for the Deutsche Mark after one week was 0.22, whereas for the dollar it was 0.53.[5]

The results for the exchange rates offer the most promising evidence for GARCH-M models and suggest that volatility strengthened the Swiss franc during the 1980s with the opposite result observed for the 1990s. The volatility coefficient in Table 3 is negative for the whole sample period and the 1980s for each of the three exchange rates. However, it is significant only for the dollar in both of these sample periods and is significant for the yen only during the 1980s. The volatility measure reverses sign for all three exchange rates during the 1990s; however, it is significant only for the dollar.

1.5 Real estate prices

Despite the recognition that the Swiss housing market is less liquid than in most European countries, it is quite common for Swiss pension and life insurance funds to hold large shares of their assets in domestic real estate. Two arguments have been advanced for including real estate in portfolios of financial assets: (i) diversification benefits stemming from the less than perfect correlation of real estate with the other assets included in the portfolio, and (ii) the better protection against inflation provided by real estate.

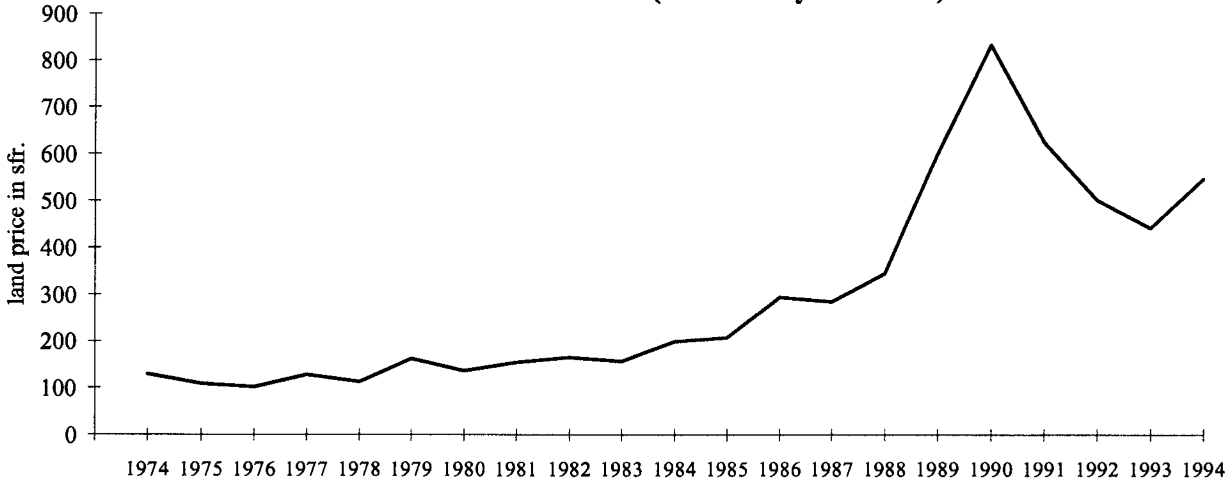
Swiss real estate prices have fluctuated considerably in recent years. As will be discussed further in Section 3, the most recent boom-bust phase had grave consequences not only for investors, but also for the banking sector. The average land price in Zurich, depicted in Figure 4, captures the main events of the last twenty years. The pre-1985 period is marked by low volatility and steady

5 The weekly persistence is defined as $(\alpha_1+\alpha_2)^5$.

annual (average) growth of just under 10%. The period of price misalignment from 1987 to 1990 represents the speculative boom. During this period average land prices in the Zurich area jumped from 300 to 825 Sw.fr./m². The most recent price rebound in 1994 suggests that real estate prices continue to be subject to higher volatility than during the 1975-85 period.

Figure 4

Average land prices for commercial and industrial use (Swiss francs/square metre) in the Swiss canton of Zurich (without city of Zurich)

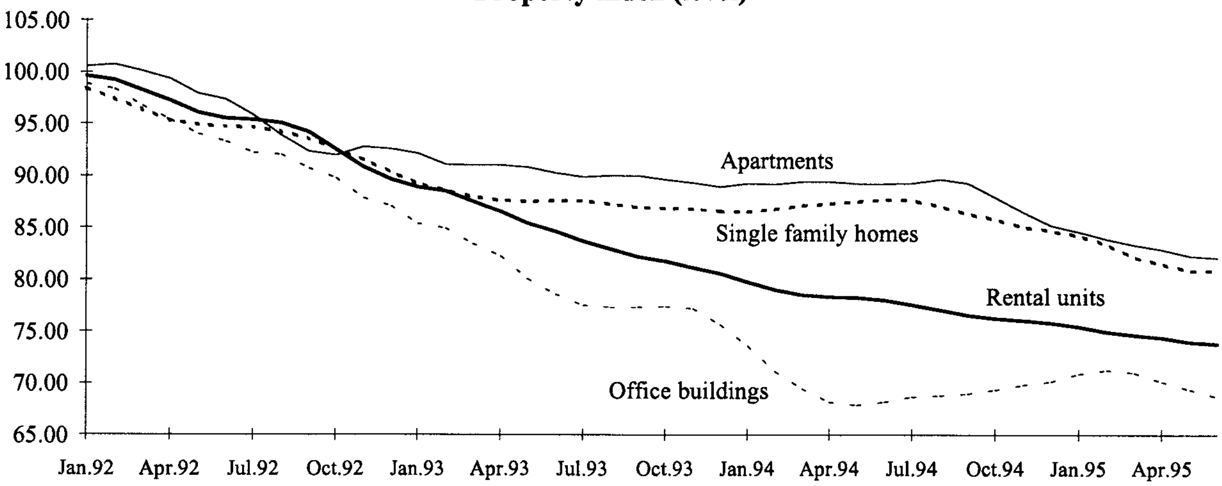


Source: Statistische Berichte des Kantons Zürich, Heft 2/1995.

The four national property markets (rental, office, apartment and homes), which are tested for GARCH effects, are plotted in Figure 5. They each show a downward trend reflecting only the bust phase of the most recent inflation cycle; however, the fall in the index has been strongest for the rental and office building market. Figure 6 plots the volatilities for the different property markets. Office buildings registered the biggest price swings. This result is confirmed by the standard deviations given in Table 1. The standard deviations at all frequencies for office buildings are almost twice as large as those for rentals and homes.

Figure 5

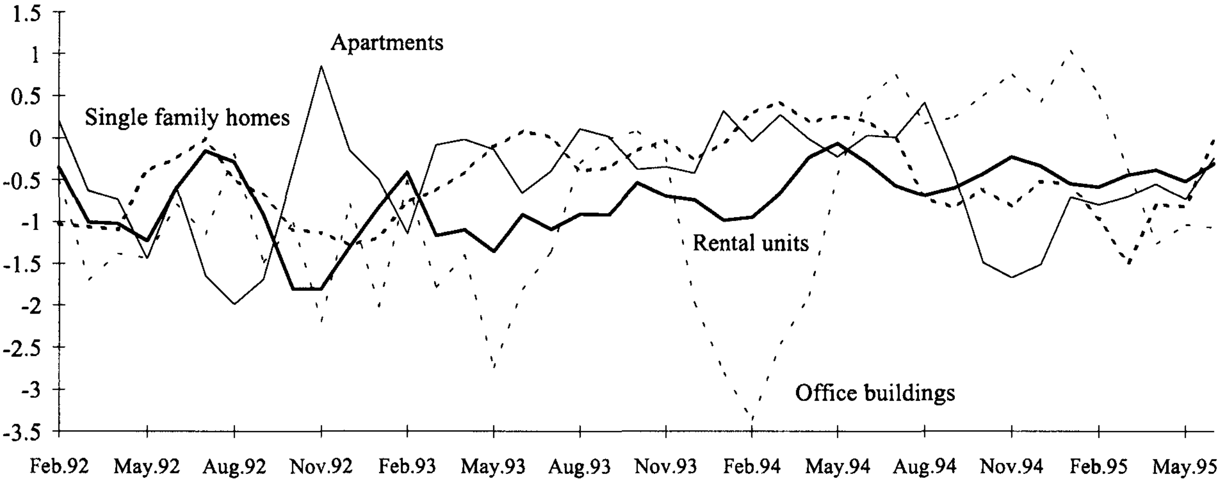
Property index (level)



Sources: Swiss National Bank (1995; A180); Das Schweizerische Bankwesen im Jahre 1994, Zurich.

Figure 6

Monthly percentage change in real estate property



The volatility estimates for monthly real estate prices, given in Table 4, reveal that only office buildings and rental units follow a GARCH process with a high positive moving average component . The monthly estimates for apartment and single family homes do not detect any GARCH effects, suggesting that the volatilities in the different real estate markets are not similar. There is no evidence of I-GARCH or GARCH-M processes for any of the markets. The GARCH estimates in Table 4 represent only a preliminary look, because the estimates stem from a limited sample 1992:1-1995:6 and therefore have to be treated with caution.

2. Aspects of asset price volatility

The relationship between macroeconomic variables and financial market reaction has been the subject of much research effort. Hardouvelis (1984) showed that interest rates and foreign exchange rates react to M1 surprises in the United States. Pearce and Roley (1985) and Hardouvelis (1988) considered the daily response of US stock prices to announcements about various macroeconomic information and conclude that mainly unexpected changes in monetary variables have a statistically significant influence. Evidence that Swiss financial markets react to macroeconomic news has been considered in several studies; however, the results suggest that markets do not react to national news.[6] It would be of interest, however, to determine if the daily volatility of the exchange rate is affected by news stemming from the SNB. The next two subsections build on the results of the previous section and consider the influence of giro announcements and SNB interventions on exchange rate volatility within the GARCH framework.

6 Wasserfallen (1989) examined the effects of unexpected variations for a wide range of macroeconomic variables on Swiss stock indexes. His results indicate that the effects of macroeconomic news are small or obscured by a low signal to noise ratio. While this result appears to be consistent with the behaviour of other European markets, Ito and Roley (1987) and Engle, Ito and Lin (1990) show that US news may be more important than national news for the yen/dollar rate. Such event studies have not been considered for Switzerland. Alternatively, Hoesli and Bender (1992) find that inflation is negatively correlated with real estate funds.

Table 4

Volatility of real estate prices in Switzerland, February 1991 - June 1995

Variables	Single family homes	Office buildings	Owned apartments	Rental units
GARCH (1, 1) specification				
β_0	- 0.083	- 0.243	- 0.178	- 0.308
	(- 0.959)	(- 1.543)	(- 1.593)	(- 3.164)
β_1	0.781*	0.681*	0.593*	0.569*
	(6.841)	(6.376)	(4.394)	(7.524)
α_0	0.049	1.249*	0.134	0.157*
	(0.539)	(3.061)	(1.009)	(2.966)
α_1	0.027	0.198*	0.316	0.210*
	(0.103)	(1.910)	(0.797)	(2.594)
α_2	0.469	- 1.018*	0.231	- 0.888*
	(0.446)	(-21.344)	(0.371)	(- 6.838)
Likelihood value	**27.43**	**7.89**	**6.77**	**29.87**
GARCH-M (1, 1) specification				
β_0	- 1.122	- 4.157	0.232	0.075
	(- 0.046)	(- 0.509)	(0.438)	(0.169)
β_1	0.773*	0.633*	0.633*	0.663*
	(6.092)	(3.507)	(4.558)	(5.501)
β_2	3.464	5.004	(- 0.801)	- 1.088
	(0.043)	(0.472)	(- 0.799)	(- 0.827)
α_0	0.059	0.299	0.201	0.062*
	(0.304)	(0.922)	(1.347)	(2.381)
α_1	- 0.002	- 0.048	0.331	0.412
	(- 0.022)	(- 0.325)	(1.049)	(1.243)
α_2	0.346	0.549	- 0.041	0.005
	(0.155)	(0.829)	(- 0.086)	(0.032)
Likelihood value	**27.63**	**8.74**	**7.12**	**28.11**

Note: Terms in parentheses are *t* values and * denotes significance at the 5% level.

2.1 Operating procedures and giro announcements

Since the level of giros is difficult to predict and banks seek to minimise their costs between holding excess giros in a non-interest-bearing account and paying a potential penalty in the case of illiquidity, the banking sector has a keen interest in knowing the latest giro position. In forming expectations about the future demand for giros, banks only know their own demand for giros and not necessarily the market's demand. Hence, if a large change in giros is interpreted as a change in monetary policy, the market revises its expectations for giros, forcing financial assets to change. The change in expectations should influence asset prices, including the exchange rate.

The SNB publishes the giro and currency positions on the 10th, the 20th and the last day of each month. Together these variables make up the monetary base - the monetary stock that the SNB has targeted since 1980. The tri-monthly giro announcements are released in the afternoon. The announcement reaction of the Deutsche Mark rate is the difference of the 11 a.m. quotes of the day following the announcement with the 11 a.m. quotes of the announcement day. To see whether giro information heightened or dampened exchange rate volatility, the following GARCH-M specification is employed:

$$\Delta dm_{t+1'} = \beta_0 + \beta_1 g_t + \beta_2 \sqrt{h_t} + e_t$$
$$Var(e_t) = h_t = \alpha_0 + a_1 e_{t-1}^2 + \alpha_2 h_{t-1} + \alpha_3 abs(\Delta g_t) + \alpha_4 dum1_t + a_5 dum3_t.$$

The dependent variable $\Delta dm_{t+1'}$ represents the reaction variable and is defined as the change in the Deutsche Mark before and after the giro announcement; Δg_t is the change in the giro level with respect to the previous announcement. The conditional mean also includes a volatility term, $\sqrt{h_t}$. The conditional variance is composed of the GARCH (1,1) terms e_{t-1}^2 and h_{t-1} plus two sets of variables that attempt to capture giro information.

The first variable, $abs(\Delta g_t)$ represents the absolute change in the giro position. Large changes in giros may heighten uncertainty about future monetary policy and thus increase exchange rate volatility. The second set of variables attempts to determine whether the information from the three monthly announcements differs in content. A particular feature of Swiss operating procedures prior to 1988 was the enforcement of the reserve requirements only on the last day of each month.[7] As a result, the demand for giros increased and short-term interest rates rose at the end of each month, though the SNB did compensate the anticipated demand shock to some extent. This seasonal (end-of-month) pattern in the giro position is known as the ultimo effect. Once the SNB moved to a system of lagged reserve accounting with enforcement over an averaged period in 1988, the seasonal pattern disappeared. A set of dummy variables is used to distinguish whether markets are reacting to all or specific giro announcements. It is possible that under the pre-1988 period the third giro announcement in the month overlaps with the ultimo effect. In the above equation, dum1 is a dummy variable representing the first giro announcement of the month. Similarly, dum3 represents the third announcement of the month.

The results suggest that the foreign exchange market reacted to the ultimo effect stemming from the SNB's operating procedures and not from the giro announcements. To show this result, first the correlation between giros and the exchange rate is established. Next, this correlation is shown to be dependent on the pre-1988 ultimo effect. The estimated GARCH models shown in Table 5 find that the change in giros is significant in the conditional mean but not in the conditional variance, see α_1 and β_3 of Model 1 in Table 5. The results given in column 3 of Model 1 reveal that the GARCH-M specification can be rejected. The volatility parameter is found to be insignificant.

To understand whether the Deutsche Mark reactions are dependent on giro information stemming from specific dates, two tests were conducted. First, the model was estimated over the full sample with $abs(\Delta g_t)$ set to zero after 1988. The result in column 4 reveals that the log likelihood of this model is higher than those in columns 1, 2 and 3 of Model 1, suggesting that information on giro positions became less important after 1988. This result suggests that the giro reaction is dependent on the SNB's reserve requirements. The second test considers whether giro reactions were of the same strength throughout the month. The results for Model 2 of Table 5 reveal that the third giro announcement of the month is responsible for the giro reactions found in Model 1. The results in

7 The importance of the liquidity effects and the reaction of the SNB to the sharp increases in short-term interest rates on the foreign exchange market has been considered by several authors. Giovannini (1994), using end-of-month dummy variables, finds that the liquidity shocks helped explain *ex ante* returns in the foreign exchange market. On the other hand, Wasserfallen and Kürsteiner (1994) are unable to detect an influence from daily changes in the giros on exchange rates.

Table 5

Giro announcements and exchange rate reaction

Model 1:
$$\Delta s_t = \beta_0 + \beta_1 \Delta giro_t + \beta_2 \sqrt{h_t}$$
$$h_t = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1} + \alpha_3(\Delta giro_t)$$

Model 2:
$$\Delta s_t = \beta_0 + \beta_1 dum1 \cdot \Delta giro + \beta_2 dum2 \cdot \Delta giro + \beta_3 dum3 \cdot \Delta giro + \beta_4 \sqrt{h_t}$$
$$h_t = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1} + \alpha_3 dum1 + \alpha_4 dum2 + \alpha_5 dum3$$

Variables	**Model 1**				**Model 2**		
	1	**2**	**3**	**4**[1]	**5**	**6**[2]	**7**[2]
β_0	- 0.044* (- 2.287)	- 0.039* (- 1.991)	- 0.040 (- 0.204)	- 0.021 (- 1.335)	- 0.055 (- 2.863)	- 0.190 (- 1.071)	- 0.058* (- 2.764)
β_1	0.004* (3.482)	0.004* (3.076)	0.004* (3.474)	0.004* (3.168)	- 0.000 (- 0.660)		
β_2			- 0.017 (- 0.024)		0.003 (0.966)		
β_3					0.004* (4.576)	0.136* (2.621)	0.157* (3.920)
β_4						0.510 (0.738)	
α_0	0.036* (3.796)	0.037* (2.138)	0.037* (3.705)	0.074 (0.000)	0.074 (0.000)	0.020 (1.686)	0.034* (3.113)
α_1	0.112 (1.389)	0.059 (0.873)	0.109 (1.365)	0.197* (3.000)	0.372* (5.544)	0.108 (1.618)	0.100 (1.300)
α_2	0.410* (2.638)	0.348 (1.193)	0.409* (2.561)	0.550* (5.809)	0.569* (11.653)	0.531* (3.152)	0.441* (2.552)
α_3		0.000			0.010 (1.085)		
α_4					- 0.010* (- 1.982)		
α_5						0.023 (1.501)	0.000 (0.060)
Likelihood value	**206.2**	**206.5**	**206.2**	**217.1**	**184.5**	**210.0**	**209.3**

Note: Terms in parentheses are t values and * denotes significance at the 5% level.

[1] In the conditional mean the independent variable $\Delta giro_t$ is zero after 1988. [2] In the conditional mean each of the dummy variables *dum*1, *dum*2, *dum*3 is no longer multiplied by $\Delta giro$.

columns 5-7 show that dum3 is a better explanatory variable than either giro or giro*dum1. The likelihood value for the model with dum3 is the highest. I interpret these results to imply that giro announce ments did not provide new information to the market. Rather the Deutsche Mark reacted to the ultimo effects, stemming from the pre-1988 reserve requirements.

2.2 SNB exchange rate intervention and exchange rate volatility

The vast literature of foreign exchange interventions reports only limited empirical results with respect to foreign exchange rate intervention and exchange rate volatility. One position is that interventions can influence not only the level of the exchange rate, but can also calm markets. Empirically, this implies that interventions decrease market volatility. Dominguez (1993), using a GARCH specification, shows that announced interventions by the Federal Reserve decrease the conditional variance of the yen/dollar and Deutsche Mark/dollar rate, whereas secret interventions tend to heighten exchange rate volatility. Her results support the claim that ambiguous signals lead to higher volatility. Similarly, Osterberg and Westmore Humes (1995) find evidence that interventions influence the volatility of the yen/dollar and Deutsche Mark/dollar rate; however, their results are sample dependent.

The empirical tests of SNB interventions on the volatility of the Swiss franc/US dollar rate find a different result: intervention policy is ineffective in influencing the level of the exchange rate and can increase the volatility of the exchange rate. The empirical results are derived from daily data covering the period from January 1982 to June 1995.[8] Prior to the Louvre accord in 1987 the SNB undertook limited interventions with respect to the US dollar. During the period 1987-90, SNB interventions were more frequent; however, after 1991 the SNB curtailed its presence in the market.

The specification used to capture the intervention effects on the conditional variance follows Dominguez (1993) and Osterberg and Westmore Humes (1995):

$$\Delta s_t = \beta_0 + \beta_1 s_{t-1} + \beta_2 I_{t-1} + \beta_3 \sqrt{h_t} + e_t, \qquad e_t \sim \text{student-t distribution}$$

$$\text{VAR}(e_t) = h_t = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1} + \alpha_3 |I_{t-1}|.$$

The conditional mean depends on past changes in the daily Swiss franc/US dollar exchange rate (s_t), SNB dollar interventions (I_t) and a volatility term defined by a GARCH (1,1) process. To determine whether the interventions heighten or calm market volatility the absolute value of interventions $|I_t|$ enters the conditional variance.

The results in Table 6 show that interventions have no immediate impact on the exchange rate. The intervention term β_2 is found to be insignificant for each of the specifications regardless of the sample period. The lagged changes in the exchange rate (β_1) are also found to have no effect on the Swiss franc/US dollar rate (see columns 1, 2, 4 and 5 in Table 6). The volatility term enters significantly in the conditional mean only for the full sample period (see columns 1 and 2 in Table 6). Note, the sign of the volatility term (β_3) changes in the later sample period (see columns 4 and 5). This result is a reconfirmation of the GARCH-M results of Table 3.

Interventions play a more prominent role in the conditional variance. The estimates find that interventions increase exchange rate volatility, a result at odds with Dominguez's (1993) findings for the Deutsche Mark/US dollar rate. Although SNB interventions are found to be significant for each of the specifications listed in Table 6, the influence of SNB interventions on exchange rate volatility is small. The intervention parameter α_3 is close to 0.001 in all the estimates, implying that an intervention of one billion dollars is needed to increase the exchange rate volatility by 1%.

The intervention results for exchange rate volatility appear disappointing because one can interpret them to imply that the SNB is unable to calm markets. However, if the market interprets interventions as a source of news, the intervention result is consistent with event studies. The one-day reaction to interventions may be too short an interval for determining whether central banks can calm markets for a given period of time.

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8 Since 1982 the SNB has announced its interventions to the public. Hence, the discussion by Dominguez and Frankel (1993) concerning the differing effects of reported versus unreported interventions does not apply to the Swiss case.

Table 6

Intervention effects on the Swiss franc/US dollar exchange rate

Model: $\Delta s_t = \beta_0 + \beta_1 \Delta s_{t-1} + \beta_2 I_{t-1} + \beta_3 \sqrt{h_t} + e_t,$ $\quad h_t = \alpha_0 + \alpha_1 + e_{t-1}^2 + \alpha_2 h_{t-1} + \alpha_3 |I_{t-1}|$

Variables	Exchange rate					
	1980:1:1 - 1995:6:31			1987:1:1 - 1995:6:31		
	1	2	3	4	5	6
β_0	0.109*	0.108*	0.002	- 0.156*	- 0.156*	- 0.023
	(2.216)	(2.208)	(0.145)	(- 2.055)	(- 2.069)	(- 1.414)
β_1	- 0.028	- 0.028		- 0.039	- 0.040	
	(- 1.624)	(- 1.629)		(- 1.650)	(- 1.685)	
β_2	- 0.000		- 0.000	0.000		0.000
	(- 0.273)		(- 0.010)	(0.149)		(0.153)
β_3	- 0.146*	- 0.145*		0.177	0.177	
	(- 2.205)	(- 2.196)		(1.756)	(1.767)	
α_0	0.018*	0.017*	0.018*	0.026*	0.026*	0.027*
	(6.568)	(6.607)	(6.836)	(6.183)	(6.219)	(6.168)
α_1	0.077*	0.076*	0.077*	0.075*	0.075*	0.077*
	(9.623)	(9.637)	(9.704)	(6.856)	(6.900)	(6.990)
α_2	0.897*	0.898*	0.898*	0.884*	0.884*	0.880*
	(95.799)	(96.402)	(97.938)	(69.713)	(70.679)	(68.672)
α_3	0.001*	0.001*	0.001*	0.001*	0.001*	0.001*
	(3.496)	(3.729)	(3.527)	(2.915)	(3.666)	(2.854)
Likelihood value	**- 1,020.5**	**- 1,020.5**	**- 1,023.9**	**- 556.5**	**- 556.5**	**- 559.2**

Note: s_t is the Swiss franc/US dollar rate, I_t is the intervention in US dollars. Terms in parentheses are t values and * denotes significance at the 5% level.

3. The emergence of new financial instruments and investment strategies

New investment strategies and new financial instruments are often blamed for the observed increase in financial volatility. Extensive evidence on the role of financial instruments in Swiss markets is still lacking, however. The increased institutionalisation of Swiss pension funds, the internationalisation of portfolio investments and the use of new hedging instruments, as shown in Section 1, has not led to substantial changes in the behaviour of stock prices. The single available study by Stucki and Wasserfallen (1994) examined the interactions between the markets for options and underlying shares in Switzerland. Their findings confirm the impression that the introduction of options did not change the price behaviour of stocks significantly. Although the introduction of traded options in 1988 led to a permanent increase in the price of underlying shares, the volatility of stock returns did not increase. Moreover, almost no effects of option expiration on the pricing process of the underlying shares could be found by the authors. On the other hand, the increased use of options, futures and swaps has changed the structure of price dynamics in the market. Because of the lower transaction costs for derivative instruments than for the underlying instruments, new information often manifests itself first in the derivative markets and then in the underlying instruments.

The rise in long-term interest rates and their volatility in the early 1990s did coincide with the increased demand for synthetic bonds. However, because these bonds are not actively traded and their share of the market remains small, it is doubtful that these instruments have contributed heavily to the observed increase in volatility. Synthetic bonds are constructed so that their cash flows and sometimes their risk/reward characteristic replicates those of other assets or liabilities and are thus indexed to a particular stock, commodity or a basket of goods. To understand how the rise and fall in the supply of synthetic bonds is tied to the volatility of long-term interest rates, let us first consider the evolution of the daily change in government bonds. Figure 2 showed that the rise in the daily change in government bonds during the 1990s has been exceptional with respect to the recent past. Next, Table 7 notes that the size and number of synthetic bonds are closely related to the standard deviations of long-term interest rates (see terms in brackets). Although the overall size of the market for synthetic bonds remained small during the 1991-95 period, the number of issued bonds in 1993 was highest when the standard deviation of long-term rates was highest. Similarly, the number of issuances was the lowest in 1991 and 1995 when the volatility for long-term rates was lower.

Table 7

Synthetic bonds in Switzerland

	Number of synthetic bonds issued	**Percentage of market**	**Size of market for synthetic bonds (in millions)**	**Average interest rate of non-government bonds (in %)**	**Average interest rate of government bonds (in %)**
1991	177	3.3	954.5	6.82	6.24
				(0.08)	(0.06)
1992	21	3.4	937.5	6.42	6.36
				(0.25)	(0.32)
1993	42	4.9	2,210.0	4.87	4.48
				(0.51)	(0.47)
1994	27	2.2	698.2	4.76	4.79
				(0.46)	(0.38)
1995	5	0.2	40.1	4.68	4.68
(15th August)				(0.08)	(0.14)

Note: Values in parentheses are standard deviations.

Most institutional investors in Switzerland have a strong preference for domestic fixed income securities. At the end of 1990, stocks made up only 10% in the portfolios of pension funds and insurance companies and the share of foreign investments in their portfolios was 9.2% (see Rich and Walter (1993)). To limit the interest rate risk in their portfolios and to increase their performance, institutional investors in Switzerland are using structured products that guarantee a minimum return. However, it is difficult to say how diffuse these products are and what their impact has been on the market.

Positive feedback trading rules (portfolio insurance, stop loss orders) are not widely used in Switzerland. Because such portfolio management techniques increase the slopes of the demand and the supply curve for securities they might increase price fluctuations. However, to date there is no clear evidence that these techniques increase price volatility in Switzerland.

4. Episodes of price misalignment and SNB reaction

A closely related concept to volatility is price misalignment. International events - such as the 1987 October Crash in the stock market, the 1980s bubble in property markets and the 1994 inflation scare in the bond market - are often interpreted as price misalignments. These events have made their presence felt also in Swiss markets. The next subsections discuss price misalignments in various markets and the SNB's response.

4.1 Exchange rate management 1978-79 [9]

The period of exchange rate management (1978-79) represents the first episode when the SNB altered its policy because of perceived price misalignments in the FOREX market. Before the period of exchange rate management the SNB defined its policy strategy clearly in terms of monetary targeting. Until 1977 the appreciation of the Swiss franc seemed to reflect economic fundamentals in that Swiss inflation was lower than foreign inflation. The continued appreciation of the Swiss franc at the end of 1977 and during 1978 was quickly perceived by the public and the SNB to be no longer consistent with economic fundamentals. The competitive position of the export industry eroded quickly. The SNB was confronted with increasing pressures to focus greater attention on the exchange rate. The SNB was unable to restrain the conflict between the appreciating currency and the monetary target in 1978. Thus, the SNB opted to abandon temporarily its strategy of monetary targeting. A ceiling on the Deutsche Mark/Swiss franc was announced in October 1978. No monetary target was made public for 1979.

The policy shift caused the monetary aggregates to expand considerably in the fourth quarter of 1978 and the first quarter of 1979. Thereafter, the Swiss franc fell to a level that was regarded as more in line with fundamentals. At the end of 1979, the SNB returned to its policy of monetary targeting. Although the SNB hoped that the temporary relaxation of monetary targeting in 1978 would not jeopardise price stability, this was not the case. Inflation rose in 1979 because of the second oil shock. However, as a possible consequence of the 1978 policy shift, inflation increased further in 1980. The period of disinflation began in the fourth quarter of 1981.

4.2 The October 1987 stock market crash

The October 1987 stock market crash marks the second episode when the SNB redefined its policy course on account of volatility in financial markets. Although trends and the variance of stock prices receive almost no weight on the SNB's checklist of economic indicators, it was felt that the global crash came at an inopportune time when there were already signs of an economic slowdown in Switzerland and elsewhere in Europe. In addition, the US dollar reached new record lows against the Swiss franc shortly after the crash. These events increased the uncertainty with regard to the future economic prospects in Switzerland. Fears about a possible economic downturn led the SNB to signal to the public that it intended to follow a more relaxed policy course for the coming year. Despite the fact that the SNB had overshot its 1987 target, it raised its money supply target for the adjusted monetary base from 2 to 3% in 1988. The 1988 target represented a departure from previous SNB practice of steadily lowering the annual monetary targets. It was the first time the SNB had increased its monetary target since 1975.[10]

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9 This subsection draws heavily from Rich (1995).

10 As noted in Rich (1992), the 3% target represented a planned target the SNB would have followed had no financial innovation occurred in 1987-88. The SNB anticipated a decline in base demand due to the introduction of the Swiss Inter Bank Clearing System and the modification of the cash reserve requirements. At the outset of these measures it was difficult to make any forecasts regarding the fall in base demand.

The course of monetary easing in the first half of 1988 resulted in strong M1 money growth and a sharp fall in the short-term interest rates. The SNB realised in the summer of the same year that the anticipation of a severe slowdown in economic activity stemming partly from the stock market crash was unfounded. Instead increasing signs of a global economic upswing were present and the SNB returned to a restrictive monetary policy. By the end of 1988 short-term interest rates were above the level before the stock market crash.

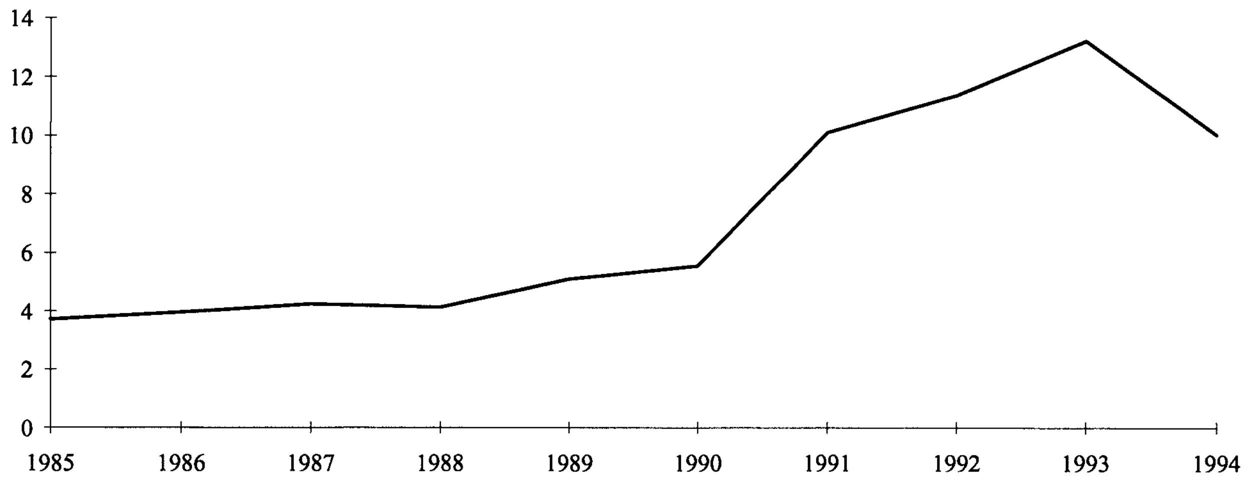
4.3 Real estate price volatility and the banking sector

In the late 1980s inflation reached over 5% and the real estate market was caught in a speculative frenzy. Banks lent freely and accepted inflated real estate as collateral. The origin of the sharp price increase lies at the hands of a somewhat expansive monetary policy followed by looser lending requirements in a more competitive banking environment. Supply-side measures cannot be blamed, because no major tax reforms relating to housing finance were introduced during this period. The prolonged bust period from 1991 to 1993 was a result of tight monetary policy beginning in 1989. As the economic slowdown finally set in, real estate prices started to tumble quickly in 1991. Borrowers failed, and banks were left holding overvalued real estate. Figure 7 shows the evolution of the massive loan losses experienced over the most recent business cycle.

Figure 7

Losses, depreciation and provisions

(in billions of Swiss francs)

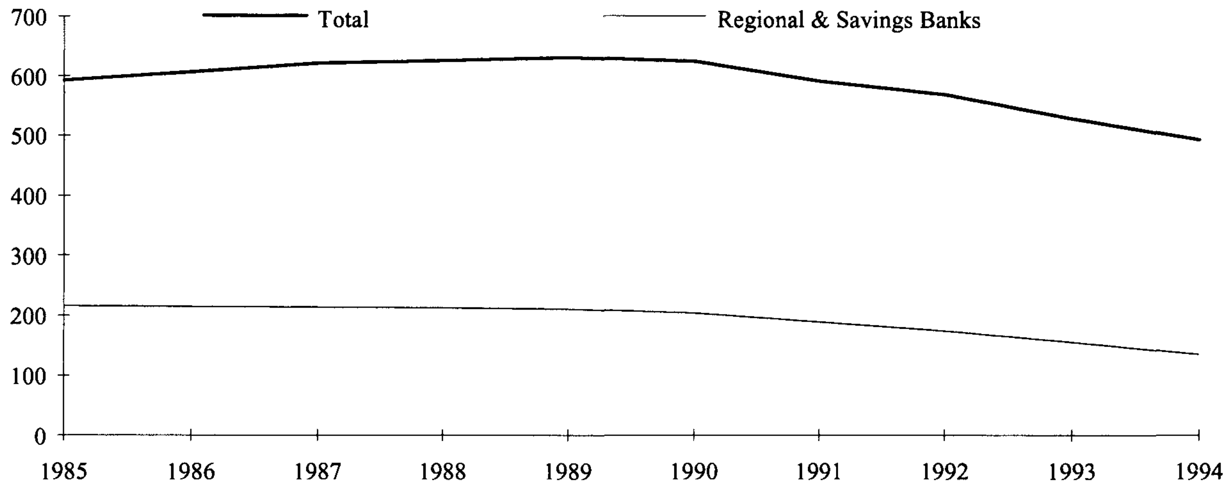


Sources: Swiss National Bank (1995; A180); Das Schweizerische Bankwesen im Jahre 1994, Zurich.

The increase in loan losses endangered the soundness and competitiveness of regional and savings banks, several cantonal banks, and even a larger commercial bank. As a consequence, massive restructuring of the banking sector took place in the early 1990s. Many ailing banks, most of them smaller mortgage banks, were forced to merge and lost their independence. Figure 8 shows that the regional and savings banks were hit the hardest. It is expected that this trend could continue for several years. The attitude of the SNB and the Federal Banking Commission, which is responsible for the supervision of the Swiss banks, is characterised by a reluctance to intervene in the market process. No ailing bank has been taken over by the Federal Government.

Figure 8

Number of banks 1985-94 (end of year)



Sources: Swiss National Bank (1995; 22); Das Schweizerische Bankwesen im Jahre 1994, Zurich.

4.4 The 1994 inflation scare in the international bond market

The behaviour of the international bond market including the market for Swiss government bonds was paradoxical in 1994. In reference to Figure 2, it was commented earlier that the yield on Swiss government bonds is characterised by three humps during the 1980-95 period. The first two humps are consistent with periods of high inflation; however, the most recent rise in 1994 occurred during a period when inflation averaged less than 1%. Swiss government bonds rose more than 150 basis points during the period from December 1993 to September 1994. The bond rates returned to their historical average of 4% in September 1995. Although rates on international bonds rose by a greater amount, the Swiss experience remains puzzling because, unlike in many other countries, Swiss inflation was extremely low and internal demand was weak during this period.

A popular explanation, particularly for the 1994 rise in US long-term interest rates, is Goodfriend's inflation scare hypothesis.[11] Goodfriend (1995) defines an inflation scare as a long-term interest rate rise in the absence of an aggressive tightening in the central bank's instrument, since it tends to reflect rising expected long-run inflation. Inflation scares confront the central banker with a policy dilemma. Higher short-term real rates are needed to avert the inflation scare. However, this leads to adverse effects for economic activity. Failure to respond quickly could instil a loss of credibility. Higher inflation materialises, because workers and firms ask for wage and price increases in order to protect themselves.

Though parallels exist between the SNB's cautious stance and the rise in long-term interest rates, the inflation scare hypothesis does not fit the Swiss experience. The SNB's cautious policy stance for 1994 was pre-announced before long-term rates bottomed out in January 1994. At the end of 1993, the SNB announced a policy programme where base growth should be just above 1%. It also anticipated a continued decline in inflation and a slight fall in money market rates for 1994. The policy programme was designed such that policy would not continue the expansionary course of 1993.

11 Other hypotheses consider the role of government debt. Ganley and Noblet (1995) give an international perspective of the bond yield changes in 1994.

Despite the rise in long-term rates, the record shows that the SNB stuck to its announced policy course of caution. Base growth was slightly below the targeted level. Overnight rates fell continuously throughout the year, though money market rates remained stable at 4%. The rise in long-term rates did influence monetary conditions in that they are an important component of broad money growth. The rise in long-term rates was responsible for the slowdown in broad money growth in the second half of 1994.

Conclusions

Volatility does not have similar properties across Swiss financial markets. Despite the increased use of financial instruments, volatility in the stock market experienced no notable changes between the 1980s and 1990s. This was not true for the bond, property, and foreign exchange market. Even in the markets where volatility increased recently, there is greater evidence of mean reversion in volatility during the 1990s than during the 1980s. Only in the foreign exchange market is there evidence that volatility drives asset prices, however not always uniformly. The Swiss franc appreciated during periods of excess volatility in the 1980s, yet volatility tended to depreciate the Swiss currency in more recent episodes.

One source of volatility is the SNB's own operating procedures. The reserve requirements prior to 1988 created end-of-month liquidity effects in the short end of the money market, which led to spillover effects in the FOREX market. Similarly, the evidence from the GARCH estimates finds that SNB interventions do not calm markets. If anything, interventions tended to augment rather than dampen exchange rate volatility.

The SNB has reacted differently to the various episodes of financial asset volatility. The stock market crash in 1987 created a false scare. It had instilled the temporary belief that an expansionary course was necessary; however, monetary conditions were altered once the pessimistic view turned out to be unwarranted. On the other hand, the recent massive restructuring in the banking sector as a consequence of the inflated real estate prices did not force the SNB to deviate from its policy of price stability.

APPENDIX

Interest rate volatility and money demand

Walsh (1984) and others argue that measures of risk or interest rate volatility influence money demand. Money demand specifications need to include a risk-return tradeoff. The relevant tradeoff is safe money versus risky bonds or some other interest-paying financial asset. Money fulfils both a transactions and portfolio function, and measures of risk and return to holding financial assets enter explicitly in money demand decisions. Empirical studies by Baba, Hendry and Starr (1991) find that the risk-adjusted long-term bond yield appears to be integral for the explanation of the Missing Money episode and Great Velocity Decline for United States money demand. The study claims that failure to include such a volatility measure leads to an unstable money demand function for the United States.

Recent empirical studies of Swiss money demand have not considered volatility measures proxying risk or uncertainty as a possible remedy for unstable money demand functions. To determine whether the addition of a measure of risk in a money demand function represents a viable strategy, a model of currency demand is estimated with a GARCH-M specification. The square root of the conditional variance, which enters in the conditional mean under the GARCH-M specification, can act as a general proxy for the risk tradeoff in cases where the source of the interest rate volatility is not clearly defined.

Table A presents the empirical results of the GARCH-M model for currency demand with an error correction component. The monthly sample covers the period 1980:3-1995:6. The model's specification is given at the top of Table A. Overall, the parameter coefficients appear reasonable: the income elasticity and the feedback component of the error correction mechanism are correctly signed; however, the interest rate elasticity (β_3) is positive. The coefficient for volatility (β_5) is found to be negative with and without the inclusion of the interest rate, see columns 1 and 3 in Table A, suggesting that higher volatility leads to lower holdings of real money balances. This result is inconsistent with precautionary savings or portfolio models. The money demand function specified by a GARCH process encounters further problems if the volatility parameter is dropped from the conditional mean, see columns 2 and 4 in Table A. The simple GARCH specification for currency demand reveals that the conditional variance no longer follows an ARCH process. This result casts doubts on whether currency demand in Switzerland is influenced by a measure of risk or volatility captured by a GARCH process.

Table A

Money demand and volatility

Model: $\Delta(m-p)_t = \beta_0 + \beta_1\Delta(m-p)_{t-1} + \beta_2\Delta r_t + \beta_3\Delta y_t + \beta_4(m-p-5y)_{t-1} + \beta_5\sqrt{h_t} + e_t$

$h_t = \alpha_0 + \alpha_1 e_{t-1}^2 + \alpha_2 h_{t-1}$

Variables	Real currency 1980:3 - 1995:5			
	1	**2**	**3**	**4**
β_0	0.110*	0.076	0.117*	0.085*
	(2.505)	(2.001)	(2.727)	(2.058)
β_1	0.468*	0.325	0.450*	0.336*
	(6.921)	(3.647)	(6.583)	(3.997)
β_2	0.005*			0.004
	(2.353)			(1.968)
β_3	0.209*	0.202	0.212*	0.200*
	(26.925)	(22.085)	(27.940)	(22.214)
β_4	- 0.014	- 0.013	- 0.015*	- 0.014*
	(- 1.942)	(- 2.025)	(- 2.227)	(- 2.079)
β_5	- 2.489*		- 2.156*	
	(- 2.284)		(- 2.227)	
α_0	0.000*	0.000*	0.000*	0.000
	(5.330)	(2.456)	(4.958)	(1.892)
α_1	0.171	0.312	0.189	0.251
	(1.805)	(1.922)	(1.927)	(1.681)
α_2	- 0.473*	0.063	- 0.476*	0.128
	(- 2.550)	(0.256)	(- 2.383)	(0.374)
Likelihood value	**701.8**	**695.7**	**698.4**	**695.7**

Note: (*m-p*) denotes currency deflated by consumer prices, r_t the three-month Euro rate and y_t real retail sales. Terms in parentheses are *t*-values and * denotes significance at the 5% level.

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