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The Importance of Interest Rate Volatility in Empirical Tests of Uncovered Interest Parity

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The Importance of Interest Rate Volatility in Empirical Tests of Uncovered Interest Parity

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Abstract
Uncovered interest rate parity provides a crucial theoretical underpinning for many models in international finance and international monetary economics. Though theoretically sound, this concept has not been supported by the empirical evidence. Typically, econometric tests not only reject the null hypothesis, but also find significant slope coefficients with the wrong sign. Following the approach employed in Kool and Thornton (2004), we show that the empirical procedure conventionally used to test for UIP may produce biased slope coefficients if the true data-generating process slightly differs from the theoretically expected one. Using monthly data for ten industrial countries during the period W75-2004, we estimate the UIP relation for all possible bilateral country pairs for each of the six five-year sub-periods. The evidence supports the biasedness hypothesis: when the interest rate volatility of the anchor country is very high (very low), this estimation procedure reports significantly higher (lower) slope coefficients.

Keywords: International Financial Markets, Estimation Bias, Exchange Rate Volatility

JEL classification: F31, G15, C5

1 Introduction

Uncovered interest rate parity (UIP) is an equilibrium condition that binds together the (expected) returns on two comparable assets denominated in different currencies. It suggests that higher interest rate currencies should depreciate ex-post. Thereby, it provides a crucial theoretical underpinning for many models in international finance and international monetary economics.

Nonetheless, the empirical evidence is generally unfavorable to UIP. In fact, most empirical tests soundly reject this condition, and typically find significant coefficients with the wrong sign. Hence, they suggest that higher interest rate currencies tend to appreciate (not depreciate) ex-post. The literature has offered a number of reasons that (partially) account for this empirical "anomaly", ranging from time-varying nature of risk-premia to sophisticated econometric properties in small samples or extreme observations (Fama, 1984; Flood and Rose, 1996; Huisman, Koedijk, Kool, and Nissen, 1998; Baillie and Bollerslev, 2000; Bekaert, Wei, and Xing, 2006).

In this study we offer an alternative explanation. Following the approach employed in Kool and Thornton (2004) and Thornton (2006), we show that the empirical procedure conventionally used to test for UIP may produce biased slope coefficients if the true data-generating process slightly differs from the theoretically expected one. In this case, the slope coefficient estimator from conventional tests of UIP will not produce unbiased estimates for the true slope coefficient.

Moreover, this bias crucially depends on the interest rate volatility of the country used as anchor in the estimations. If this biasedness hypothesis is true, then more volatile interest rates will lead to lower bias and (assuming the true slope coefficient is less than unity) to higher slope coefficient estimates. The central aim of this paper is to empirically investigate the importance of interest rate volatility for (the bias of) slope coefficient estimates in conventional tests of UIP.

The rest of this paper is organized as follows. Section 2 defines the concept of UIP and presents the conventional empirical procedure used to test for it. Section 3 formally demonstrates why slope coefficient estimates from conventional tests of UIP may be biased. Sections 4 and 5 deal with data issues and results from conventional tests of UIP. Our main results on the importance of interest rate volatility are given in section 6. Section 7 provides a sensitivity analysis of the main findings and section 8 concludes.

2 Empirical Tests of Uncovered Interest Rate Parity (UIP)

The uncovered interest rate parity (UIP) is an equilibrium condition stating that the expected return on domestic asset denominated in domestic currency should equal the expected return on foreign asset denominated in foreign currency, if they only differ with respect to the currency of denomination[1]. If i_t is the interest rate on the domestic asset between time t and $t+1$, i_t^* is the interest rate on the foreign asset between time t and $t+1$, s_t is the spot exchange rate (the price of foreign currency in units of domestic currency) and $E_t(s_{t+1})$ is the expectation (at time t) for the future value of the spot exchange rate at time $t+1$, then the uncovered interest rate parity condition can be expressed by the following equation:

$$E_t\Big(\frac{s_{t+1}}{s_t}\Big)(1+i_t^*) = (1+i_t) \qquad (1)$$

[1] In this sense, the domestic and the foreign assets should be either risk-free or equally risky. Therefore, the only relevant source of risk is the nominal exchange rate.

Since the market expectation for the future value of the spot exchange rate $E_t(s_{t+1})$ is not directly observable, empirical studies usually replace it with the future realization of the exchange rate at time $t+1$[2]. In this way, they jointly test the UIP with the rational expectations hypothesis, which states that future realizations equal current rational expectations plus a white noise error-term. For reasonably small interest rates and changes in the exchange rate, condition 1 can be approximated as:

$$\Delta s_{t+1} + i_t^* \approx i_t \tag{2}$$

Where Δs_{t+1} is the realized change of the exchange rate (in percentage terms) between time t and $t+1$.

2.1 Conventional Empirical Tests of UIP

Usually, empirical tests of UIP are not based on equation 2, but on a modified version of it. In fact, since it is widely believed that interest rates follow unit-root, or near-unit-root processes, the foreign interest rate is subtracted from both sides of equation 2 in order to get (approximately) stationary processes. Therefore, empirical tests are normally conducted by regressing the change in the exchange rate on the interest rate differential according to the following specification:

$$\Delta s_{t+1} = \alpha + \beta_1(i_t - i_t^*) + \epsilon_{1,t+1} \tag{3}$$

[2] The exception are studies that use survey data on exchange rate expectations, see Frankel and Froot (1987), Chinn and Frankel (2002) or Chinn (2006), for example.

where α is a constant, possibly time-invariant risk premium, and $\epsilon_{1,t+1} \sim iid(0, \sigma^2_{\epsilon_1})$. If UIP holds, then the slope coefficient β_1 should not differ significantly from 1. Therefore, conventional empirical tests of UIP are tests of the null hypothesis that $\beta_1 = 1$[3].

2.2 Evidence from the Conventional Tests

Most empirical studies that employ regressions like 3 in order to test for UIP find that the interest rate differential fails to explain subsequent changes in the nominal exchange rate. Moreover, not only is the slope coefficient significantly different form 1, but it is usually significantly negative. In fact, negative values for the slope coefficient estimates are documented in numerous surveys of the empirical literature on UIP (see for example Froot and Thaler, 1990; MacDonald and Taylor, 1992; Engel, 1996). Values as low as -3 are found to be quite common when UIP is tested using the conventional regressions. Finally, recent evidence using short term data (between 3 months and 12 months horizons) is not more favorable to the UIP either (Chinn and Meredith, 2005; Chinn, 2006).

3 Biasedness of the Slope Coefficient Estimator When UIP Does Not Hold

Equation 3, used in conventional empirical tests of UIP, is derived after subtraction of i^*_t from both sides of equation 2, and after a specific parametrization. If the true data-generating process is not exactly described by equation 2 (with a slope coefficient of one), then the expected value of the estimator $\hat{\beta}_1$ from equation 3 might not correspond to the "true" slope

[3]In addition, some authors also check whether there is a foreign exchange premium by testing the null hypothesis $\alpha = 0$.

coefficient[4].

In fact, let us assume that the true data-generating process is given by the following equation[5]:

$$\Delta s_{t+1} + i_t^* = \beta i_t + \epsilon_{t+1} \tag{4}$$

where the slope coefficient β does not necessarily equal 1. Then, equation 3 is derived after subtraction of i_t^* from both sides of 4 and a slight rearrangement:

$$\Delta s_{t+1} = \beta(i_t - i_t^*) + (\beta - 1)i_t^* + \omega_{t+1} \tag{5}$$

The above equation corresponds to equation 3 that is usually estimated in empirical tests of UIP. However, this equation does not reduce to 4, which describes the "true" data-generating process, unless $\beta = 1$. Therefore, the expected value of the least-squares estimator for the slope coefficient from 5 will generally differ from the "true" slope coefficient:

$$E\hat{\beta} = \beta + (\beta - 1)E\frac{\Sigma(\bar{i_t} - \bar{i_t^*})\bar{i_t^*}}{\Sigma(\bar{i_t} - \bar{i_t^*})^2} - E\frac{\Sigma(\bar{i_t} - \bar{i_t^*})\bar{\omega_t}}{\Sigma(\bar{i_t} - \bar{i_t^*})^2} \tag{6}$$

where the "bar" denotes variables adjusted for the mean. Or, expressed in terms of variances and covariances:

[4]This demonstration closely follows the approach taken in Kool and Thornton (2004) and Thornton (2006) for tests of the expectations hypothesis.

[5]This equation corresponds to the equalization of the holding period returns on domestic and foreign assets. For alternative tests of UIP using this regression specification see Lothian and Wu (2005).

$$
\begin{aligned}
E\hat{\beta} &= \beta + (\beta-1)\left[\frac{Cov(i-i^*, i^*)}{Var(i-i^*)}\right] + (\beta-1)\left[\frac{Cov(i-i^*, \omega)}{Var(i-i^*)}\right] = \\
&= \beta + (\beta-1)\left[\frac{Cov(i,i^*) - Var(i^*)}{Var(i) - 2Cov(i,i^*) + Var(i^*)}\right] + \\
&+ (\beta-1)\left[\frac{Cov(i,\omega) - Cov(i^*,\omega)}{Var(i) - 2Cov(i,i^*) + Var(i^*)}\right] \qquad (7)
\end{aligned}
$$

The probability limit of this expression is given by:

$$
P\lim_{N\to\infty} \hat{\beta} = \beta + (\beta-1)\left[\frac{Cov(i,i^*) - Var(i^*)}{Var(i) - 2Cov(i,i^*) + Var(i^*)}\right] \qquad (8)
$$

Therefore, as long as $\beta \neq 1$, the second term in equation 8 will differ from zero, and $\hat{\beta}$ from conventional tests will be a biased estimate of the true slope coefficient. Moreover, the relationship between the interest rate distribution(s) and the total bias (given by the bracketed expression in equation 8) can be seen by a slight rearrangement of equation 8:

$$
P\lim_{N\to\infty} \hat{\beta} = \beta + (\beta-1)\left[\frac{\rho\delta^{1/2} - \delta}{1 - 2\rho\delta^{1/2} + \delta}\right] \qquad (9)
$$

where ρ is the coefficient of correlation between domestic and foreign interest rates, and δ is the ratio of their variances $\delta = \frac{Var(i^*)}{Var(i)}$. Hence, if the foreign interest rate is more volatile than the domestic interest rate, i.e., if $\delta > 1$, the expression for total bias, given between brackets, will be strictly negative. Moreover, if $\beta < 1$, then relatively high foreign interest rate volatility will translate into an upward-biased estimate $\hat{\beta}$ of the slope coefficient. Similarly, a relatively stable foreign interest rate will lead towards a downwards-biased estimate $\hat{\beta}$. In the rest of the paper we investigate to what extent (anchor country) interest rate volatility is important for the slope coefficient estimates from conventional tests of UIP.

4 Data Description and Empirical Specification

We use monthly observations for 10 industrial countries: Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Switzerland, UK and USA during the period January 1975-December 2004[6]. The monthly rates of change for the nominal exchange rates and the interest rate series for one-month Eurocurrency deposits are retrieved from Datastream. We estimate regressions of the type employed in conventional tests of UIP given in equation 3 for all possible bilateral country pairs for each of the six five-year subperiods: 1975-1979, 1980-1984, 1985-1989, 1990-1994, 1995-1999 and 2000-2004. Hence, we treat each of the 10 countries as domestic country and run regressions against each of the remaining 9 anchor (foreign) countries. In total, we estimate 9x9x6 = 486 regressions.

5 Results from Conventional Tests of Uncovered Interest Parity

Summary statistics for the slope coefficient estimates obtained from conventional tests of UIP are provided in table 1. Each column displays the mean, minimum and maximum values and the standard deviation of the slope coefficient estimates for each of the 10 countries, while taking the remaining 9 as anchor (foreign) countries. There are several interesting findings in this table. First, as can be seen from the first row, the average slope coefficient

[6] The interest rate time-series are shorter for the following three countries: Belgium, Italy and Japan and start only in 1978.

estimates differ markedly from 1. In line with other empirical tests of UIP, they are negative for each of the 10 countries. Moreover, the standard deviation is larger than the average values for each country, implying that the estimates are very variable. Finally, the extreme values, going from a minimum of -16.003 to a maximum of 8.179, further strengthen the evidence of an excessive variability in the slope coefficient estimates.

This variability can come from two dimensions: different time sub-periods and different anchor countries. First, the slope coefficients might differ markedly because of dramatic changes in some time-specific factors. Second, even estimates for the same time sub-period might vary due to the use of different anchor countries in the estimation. Therefore, it is instructive to make a distinction between these two sources of variability.

A graphical representation of the variability in the slope coefficient estimates is given in Figures 1, 2 and 3. Each graph in this Figure contains the slope coefficient estimates from regressions in which the domestic country is indicated in the title. Each of the nine lines corresponds to a different anchor country used in the conventional tests for the title (domestic) country.

From these graphs it can be inferred that the slope coefficient estimates for the same (domestic) country differ markedly depending on the time sub-period and anchor country used in the estimations. Moreover, large differences exist even among slope coefficient estimates for the same domestic country in the same time sub-period. In fact, they are typically higher (for most of the countries) when Italy or France is used as anchor country, and typically lower when the anchor country is Switzerland, the United States, Japan or Germany. This implies that besides variability among time sub-periods, slope coefficient estimates display large and systematic variability with respect to the anchor country as well.

6 The Effect of Interest Rate Volatility on Slope Coefficient Estimates

The previous section shed some light on the importance of the particular anchor country used in the estimations for the magnitude of the slope coefficient estimates. One possibility why slope coefficient estimates for the same (domestic) country may differ was given in section 3. That section formally demonstrated that the estimation procedure used in conventional tests of UIP introduces bias in the slope coefficient estimates. Moreover, equation 9 in that section indicates that anchor (foreign) country interest rate volatility might have an important effect on this bias, and therefore, on the magnitude of the slope coefficient estimates.

In this section, we investigate to what extent this bias is due to the anchor country interest rate volatility as suggested by the formal demonstration in section 3. For this purpose, we use two methods: visual inspection and formal (regression) analysis.

6.1 Visual Inspection

Figure 4 displays the relationship between the average interest rate volatility for each country over the entire time period and the average slope coefficient estimates from regressions in which that country is used as an anchor. It shows a strongly positive relationship, suggesting that on average anchor countries with relatively more variable interest rates are associated with relatively higher slope coefficient estimates.

Figure 5 goes one step further. It displays the relationship between anchor country interest rate volatility and slope coefficient estimates using all observations, i.e. the results from all bilateral regressions. The positive relationship indicates that the estimation procedure conventionally used to test for UIP tends to produce lower (higher) values for the slope coefficient when the anchor country has very stable (very volatile) interest rate.

Figure 6 offers a visual inspection of the relationship between anchor country interest rate volatility and total bias. The formal demonstration in section 3 (equation 9) suggested that relatively higher anchor (foreign) country interest rate volatility will, *ceteris paribus*, be associated with lower total bias for the slope coefficient estimator $\hat{\beta}$. The scatterplot in Figure 6 provides strong visual support for this negative relationship.

Furthermore, in order to get a deeper insight, in Figures 7 and 8 we display the two relationships for each country separately. As can be seen from Figure 7, the relationship between interest rate volatility and slope coefficient estimates is positive for most countries in the dataset. Moreover, Figure 7 shows a clear (sometimes very strong) negative relationship between interest rate volatility and total bias for each of the 10 countries.

Finally, several strong outliers are present in each of the scatterplots included in Figures 5, 6, 7 and 8. These outliers refer to three extreme observations of the interest rate volatility for Belgium, France, and Italy during the 2nd sub-period (1980-1984). Although they do not exercise critical influence on the relationships (if anything, their presence leads to less significant relationships), they may be interesting on their own and certainly deserve further investigation[7].

6.2 Formal (Regression) Analysis

Having shown some visual evidence in support of our argument, we now turn to a formal analysis. In order to test for the effect of interest rate volatility on slope coefficient estimates, we estimate the following type of regression

[7]The significant relations for individual countries in Figures 7 and 8 do not critically depend on them either.

for each of the 10 countries:

$$\hat{\beta}^i_{t,i^*} = \gamma_0 + \gamma_1 \sigma_{t,i^*} + \nu^i_{t,i^*}, \ \forall i = 1, 2, \ldots, 10 \tag{10}$$

where $\hat{\beta}^i_{t,i^*}$ is the slope coefficient estimate from the conventional UIP test for countries i (domestic) and i^* (anchor) for time sub-period t, σ_{t,i^*} is the interest rate standard deviation for the corresponding anchor country i^* for time sub-period t, and $\nu^i_{t,i^*} \sim iid(0, \sigma^2_{\nu^i})$ is the error term.

The results from these 10 regressions are displayed in Table 2[8]. The slope coefficient estimate γ_1 is positive for 9 out of 10 countries (the only exception being the regression for UK). Moreover, it is significant at the 1 percent significance level for 2 countries (Switzerland and US), at 5 percent significance level for 2 other countries (Belgium and Germany), and marginally (in)significant for Japan and the Netherlands. The last column of Table 2 reports the results from the pooled-OLS regression for all 10 countries. The slope coefficient is positive and significant at any conventional significance level (t-statistic equals 5.22). These regression results confirm the visual evidence shown in the previous section, suggesting that a (strong) positive relationship exists between interest rate volatility and slope coefficient estimates from conventional tests of UIP.

The second relationship is tested by estimating regressions of the following type for each of the 10 countries:

$$\tau^i_{t,i^*} = \kappa_0 + \kappa_1 \sigma_{t,i^*} + \eta^i_{t,i^*}, \ \forall i = 1, 2, \ldots, 10 \tag{11}$$

[8] The coefficients significant at 1 percent are indicated with (**) and those significant at 5 percent with (*).

where τ^i_{t,i^*} refers to total bias in the conventional UIP test for the country pair i (domestic) and i^* (anchor) at time sub-period t, σ_{t,i^*} is the interest rate standard deviation for the corresponding anchor country i^* at time sub-period t, and $\eta^i_{t,i^*} \sim iid(0, \sigma^2_{\eta^i})$ is the error term.

The results, displayed in Table 2, convey a very clear message: the slope coefficient estimate is negative for each of the 10 countries. Moreover, it is significant at 1 percent significance level for 4 countries (Canada, France, Italy, and Switzerland), at 5 percent for Belgium, and marginally (in)significant for Germany and UK. Furthermore, the results from the pooled-OLS regression for all 10 countries, displayed in the last column of Table 2, indicate a very strong negative relationship, significant at any conventional significance level (t-statistic equals -7.47). In sum, these regression tests provide overwhelming evidence in support of a negative relationship between anchor country interest rate volatility and total bias in conventional tests of UIP.

A final point worth mentioning is the high value for R^2 in these regressions. For some countries, interest rate volatility alone accounts for up to 17 percent of slope coefficient variation, and up to 36 percent of total bias variation. The corresponding figures for the pooled regression are 4.8 and 9.7 percent. This is an important result, suggesting that only one variable (anchor country interest rate volatility) explains a large part of the total variation in the (total bias of) slope coefficient estimates[9].

[9] This conclusion is even stronger when fixed-effects are included in the estimations, see the results in section 7.2.

7 Sensitivity Analysis

This section checks how robust the regression results from the previous section are to alternative specifications and estimation procedures. First, it investigates the sensitivity of these results with respect to particular sub-periods and anchor countries. Second, it re-estimates the same relations using panel estimation techniques.

7.1 Importance of Sub-Periods and Anchor Countries

In order to investigate the sensitivity of the regression results to certain time sub-periods and anchor countries, we re-estimate the regressions from section 6.2 by excluding one time sub-period or anchor country at the time. The sensitivity of the t-statistics from the first type of regressions (given by equation 10) to the exclusion of particular time sub-periods and anchor countries is displayed in Figure 9. The upper panel shows the deviations of the t-statistics from their overall value (indicated by a solid line) when one of the 6 sub-periods is excluded from the estimation. Similarly, the lower panel shows the deviations of the t-statistics when one of the 10 anchor countries is excluded from the estimation.

As can be seen from this Figure, the t-statistics are very robust to the exclusion of time sub-periods and anchor countries. In fact, all significant results from the main analysis (Belgium, Germany, Switzerland and US) retain their sign and significance. The only dramatic change happens for Canada, where the effect from almost null becomes significantly positive when the 5th sub-period (1994-1999) is excluded from estimation.

Similar sensitivity checks are presented for the second type of estimations (those based on equation 11) in Figure 10. Almost all t-statistics retain their sign, when one sub-period or one anchor country is excluded from the estimation[10]. Furthermore, most of the significant effects from the main analysis retain their significance.

7.2 Panel Estimations with Fixed Effects

The estimations presented in section 6.2 the slope coefficient estimates obtained in conventional UIP tests with 9 different anchor countries

Hence, we pooled together slope coefficient estimates obtained with different anchor countries and related them to the interest rate volatility of the corresponding anchor. In this way, we disregarded the "panel structure" of the dataset. Most importantly, we disregarded the possibility of fixed-effects. If the error term(s) contains anchor-specific, time-invariant component that is correlated with the right-hand side variable (volatility of anchor country interest rate), then we must include fixed effects in the panel estimations. These anchor-specific components may capture any unobserved characteristics specific to each domestic country-anchor country pair.

Therefore, we re-estimate equations 10 and 11 using panel data methods: random-effects and fixed-effects estimations. The random-effects results are literally the same with the ones obtained in section 6.2 and each of the significant effects retains its significance[11].

The results from fixed-effects estimations are presented in Tables 4 and 5. All coefficients retain their sign and most of them the significance from the pooled regressions in section 6.2. The only exceptions are the coefficients for Germany in the first specification and for Belgium in the second, which become marginally (in)significant[12]. In sum, this evidence shows that our

[10] The exception is the UK when the 2nd sub-period is excluded. In this case the t-statistic changes sign.

[11] Due to space considerations, we do not report the random-effect estimations in the main text. They are available from the authors upon request.

[12] For the case of Belgium, the Hausman test for non-systematic difference in slope

results are very robust to the inclusion of random and fixed effects.

8 Concluding Remarks

Our analysis suggested that slope coefficient estimates from conventional empirical tests of UIP may be biased if the true data generating process is not exactly equal to the theoretically expected one. In that case, we demonstrated that higher anchor country interest rate volatility leads to lower total bias and (assuming the true slope coefficient is less than unity) to higher slope coefficient estimates. The empirical evidence from 10 industrialized countries during the period 1975-2004 supports our argument. First, there is a very strong negative relationship between interest rate volatility and total bias for each country in our dataset. Second, higher interest rate volatility is associated with higher slope coefficient estimates for 9 out of 10 countries. Our findings are quite robust to the inclusion/exclusion of different sub-periods, anchor countries, and anchor-specific fixed-effects in panel estimations.

Several recent empirical studies attempt to "rehabilitate" UIP using different strategies. Therefore, it might be interesting to examine to what extent interest rate volatility explains the support for UIP in tests using longer horizons (Chinn and Meredith, 2005; Chinn, 2006), focusing on the very short maturity spectrum (Chaboud and Wright, 2005), or including emerging/developing economies (Bansal and Dahlquist, 2000; Frankel and Poonawala, 2004; Chinn, 2006). Finally, the empirical evidence against UIP is mainly based on studies that include G-7 countries only. Therefore, the (extremely) low interest rate volatility of the G-7 countries might be

coefficients is only marginally rejected at 5 percent, indicting that the fixed-effects results should be considered with caution.

one possible explanation for these findings that certainly deserves further research.

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Table 1: Summary Statistics: Slope Coefficient Estimates

COUNTRY	BEL	CAN	FR	GER	ITA	JAP	NL	SWI	UK	USA
mean	-1.09935	-2.9982	-0.39943	-2.05787	-0.05374	-2.71248	-1.92124	-3.62537	-1.88417	-3.4018
st.dev.	3.519356	4.220589	2.643833	4.033736	3.394885	4.385839	3.961581	3.889797	3.461045	4.87339
min	-13.048	-14.23	-7.772	-14.23	-7.296	-14.852	-16.003	-14.852	-13.582	-16.003
max	8.179	3.982	6.775	6.895	7.452	5.956	7.452	4.896	8.179	6.088

ANCHOR	BEL	CAN	FR	GER	ITA	JAP	NL	SWI	UK	USA
1975-1979	1.182	-2.27733	0.100333	-0.46567	0.578667	-0.74111	-0.97767	-2.759	0.111889	0.045667
1980-1984	-0.04689	-1.358	0.378889	-1.35656	-0.57444	-2.53922	-1.52178	-1.83789	-3.47767	-1.41156
1985-1989	-1.74622	-9.39744	0.469444	-5.26967	-0.90478	-5.35356	-4.69489	-4.864	-5.231	-8.61122
1990-1994	-0.19756	-1.19111	0.723	0.129667	5.022444	-0.351	0.145222	-1.94789	-0.89756	1.413333
1995-1999	-3.38644	0.872	-1.66722	-2.98422	-2.04322	-6.56556	-2.07744	-4.43833	-1.34022	-6.01778
2000-2004	-2.401	-4.63733	-2.401	-2.40089	-2.401	-0.72444	-2.40089	-5.90511	-0.47044	-5.82922
1975-2004	-1.09935	-2.9982	-0.39943	-2.05789	-0.05372	-2.71248	-1.92124	-3.62537	-1.88417	-3.4018

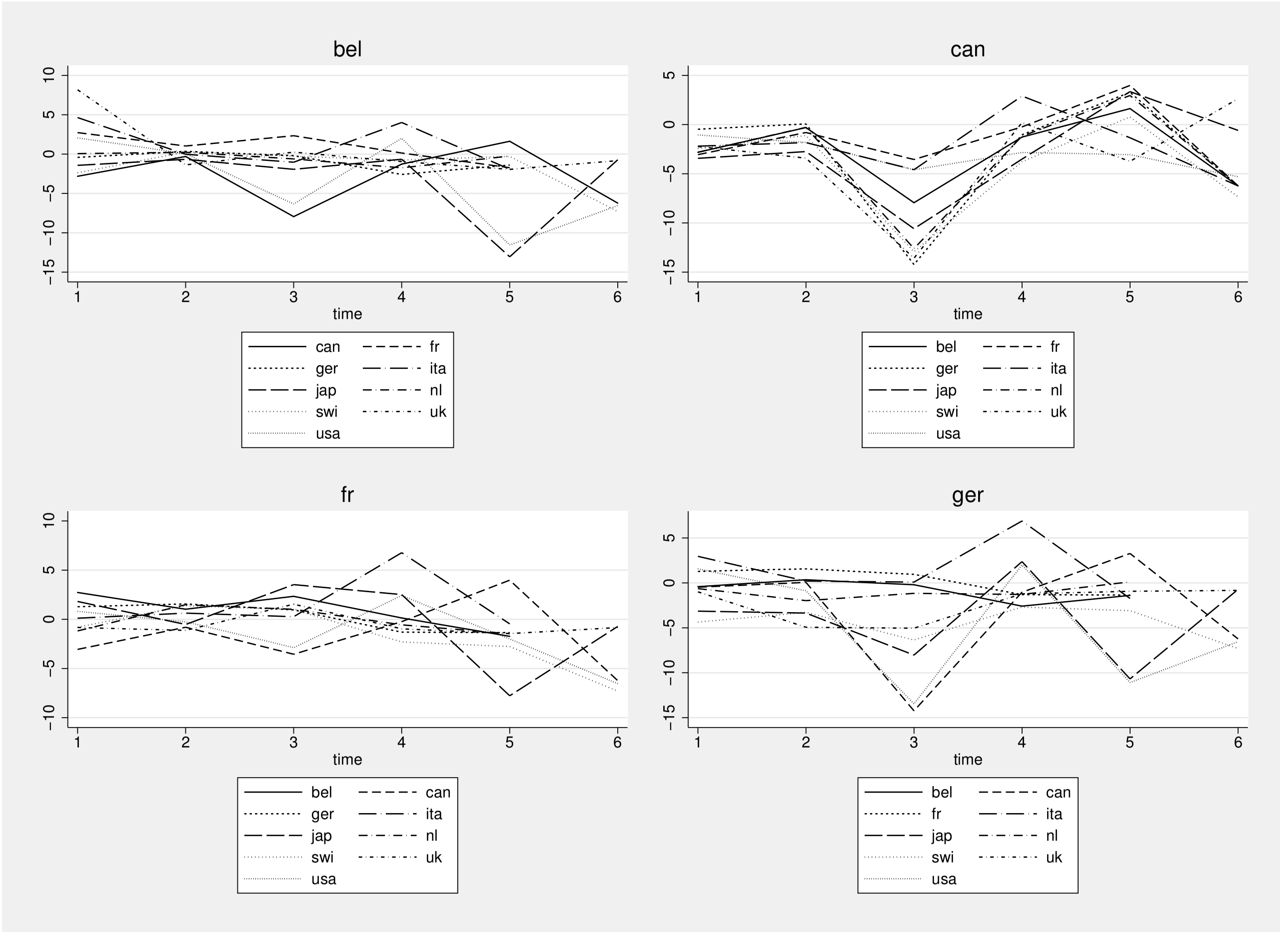

Figure 1: Estimates of the Slope Coefficient Using Different Anchor Countries

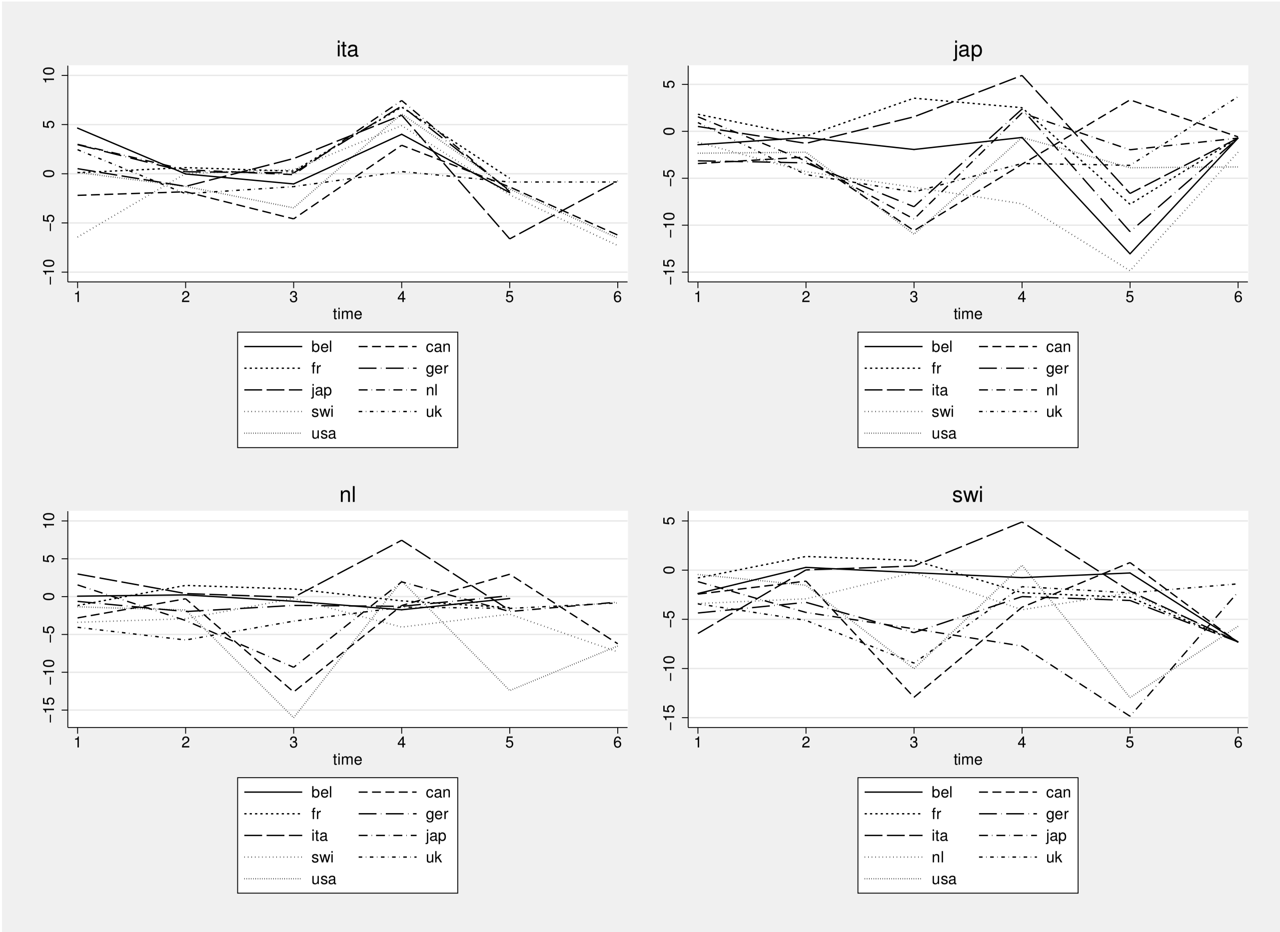

Figure 2: Estimates of the Slope Coefficient Using Different Anchor Countries

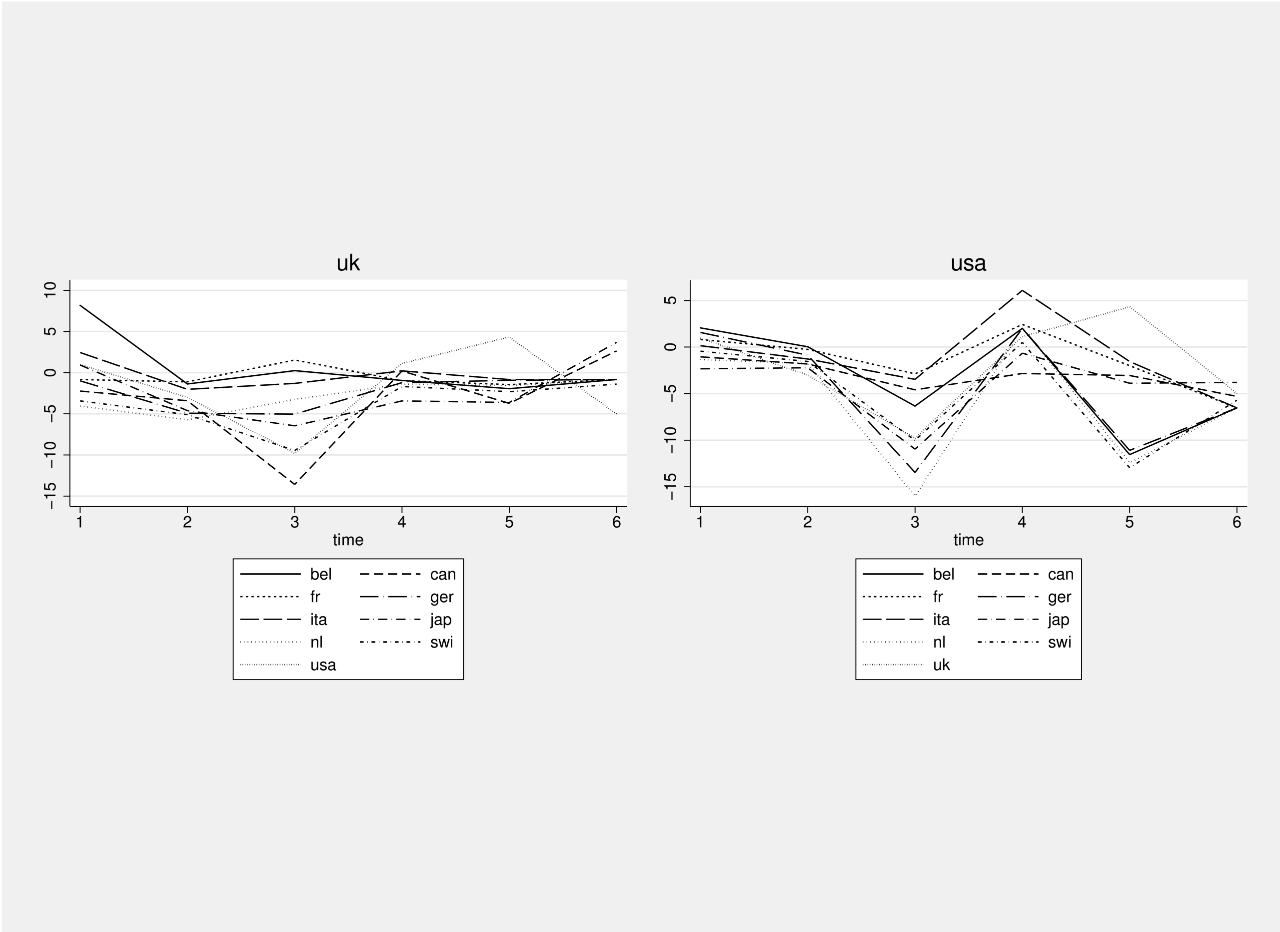

Figure 3: Estimates of the Slope Coefficient Using Different Anchor Countries

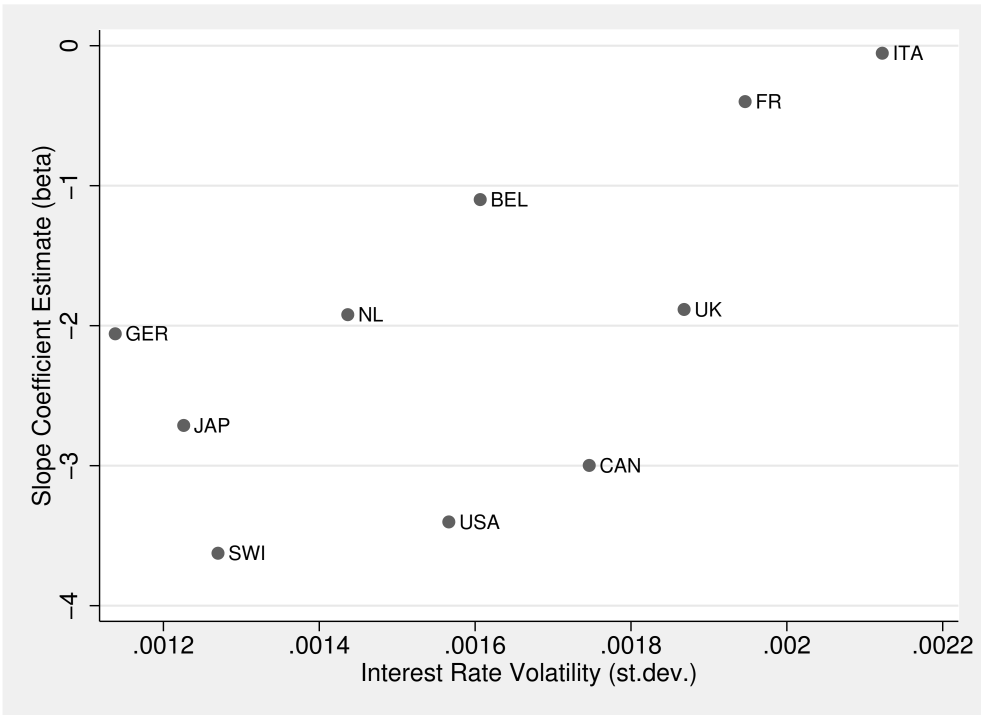

Figure 4: (Average) Interest Rate Volatility vs. (Average) Slope Coefficient Estimates

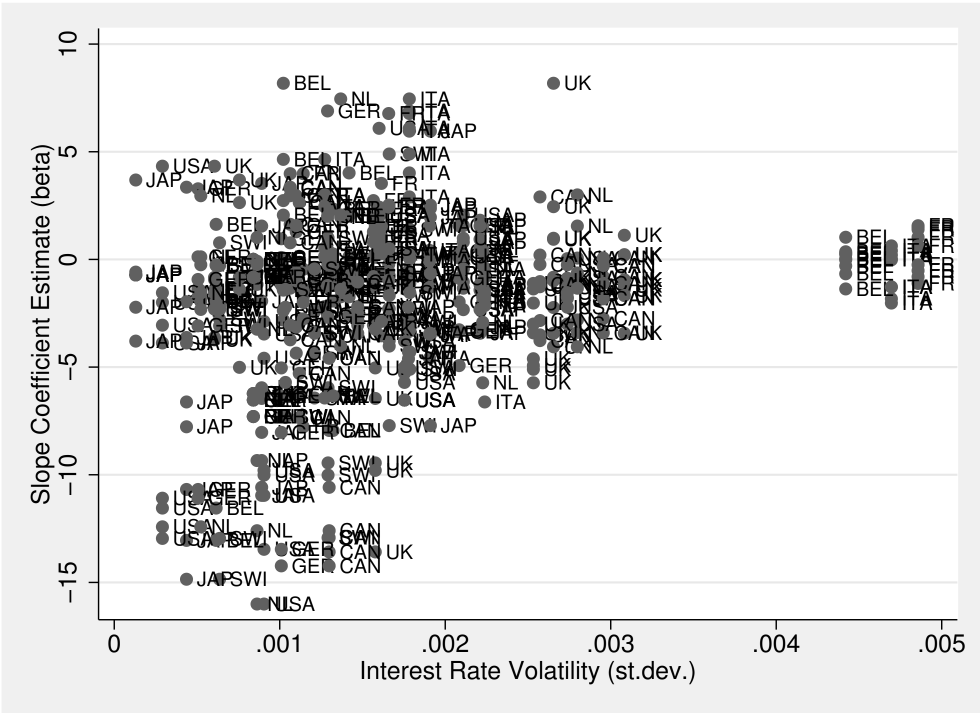

Figure 5: Interest Rate Volatility vs. Slope Coefficient Estimates (All Observations)

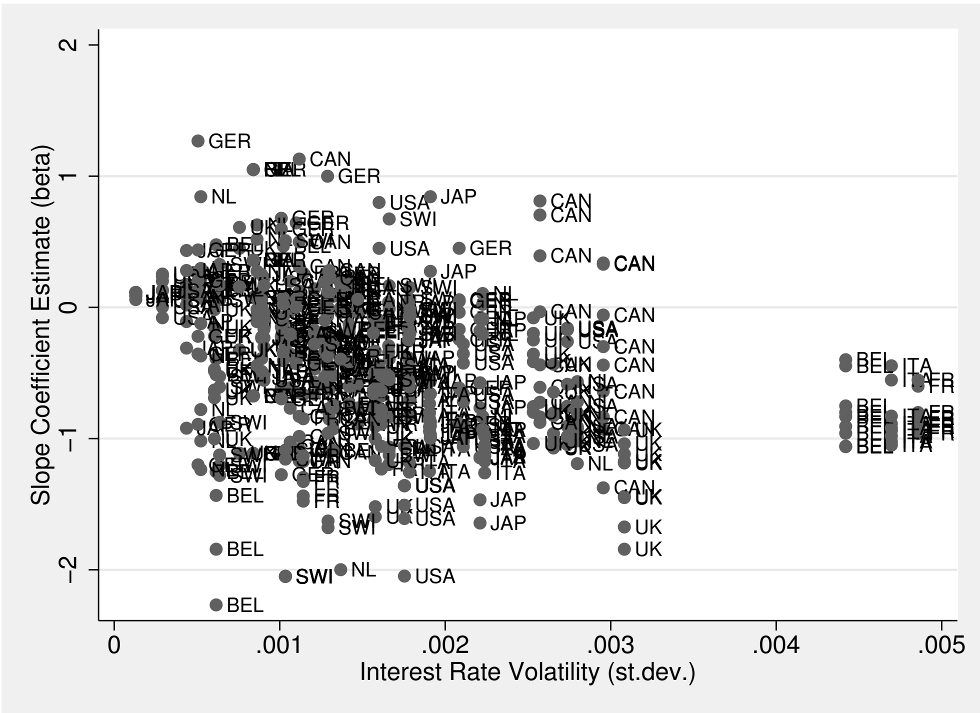

Figure 6: Interest Rate Volatility vs. Total Bias (All Observations)

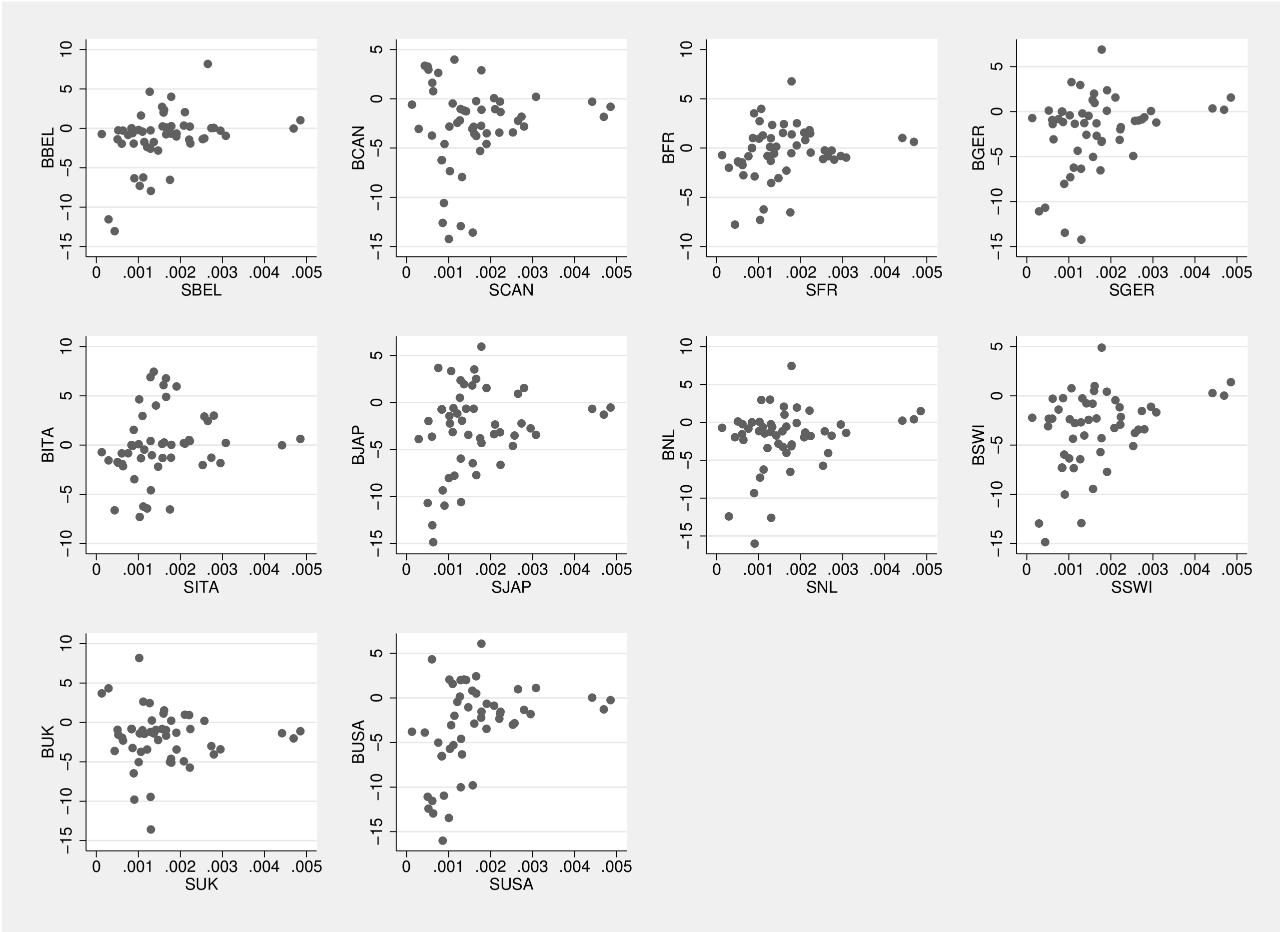

Figure 7: Anchor Country Interest Rate Volatility and Slope Coefficient Estimates

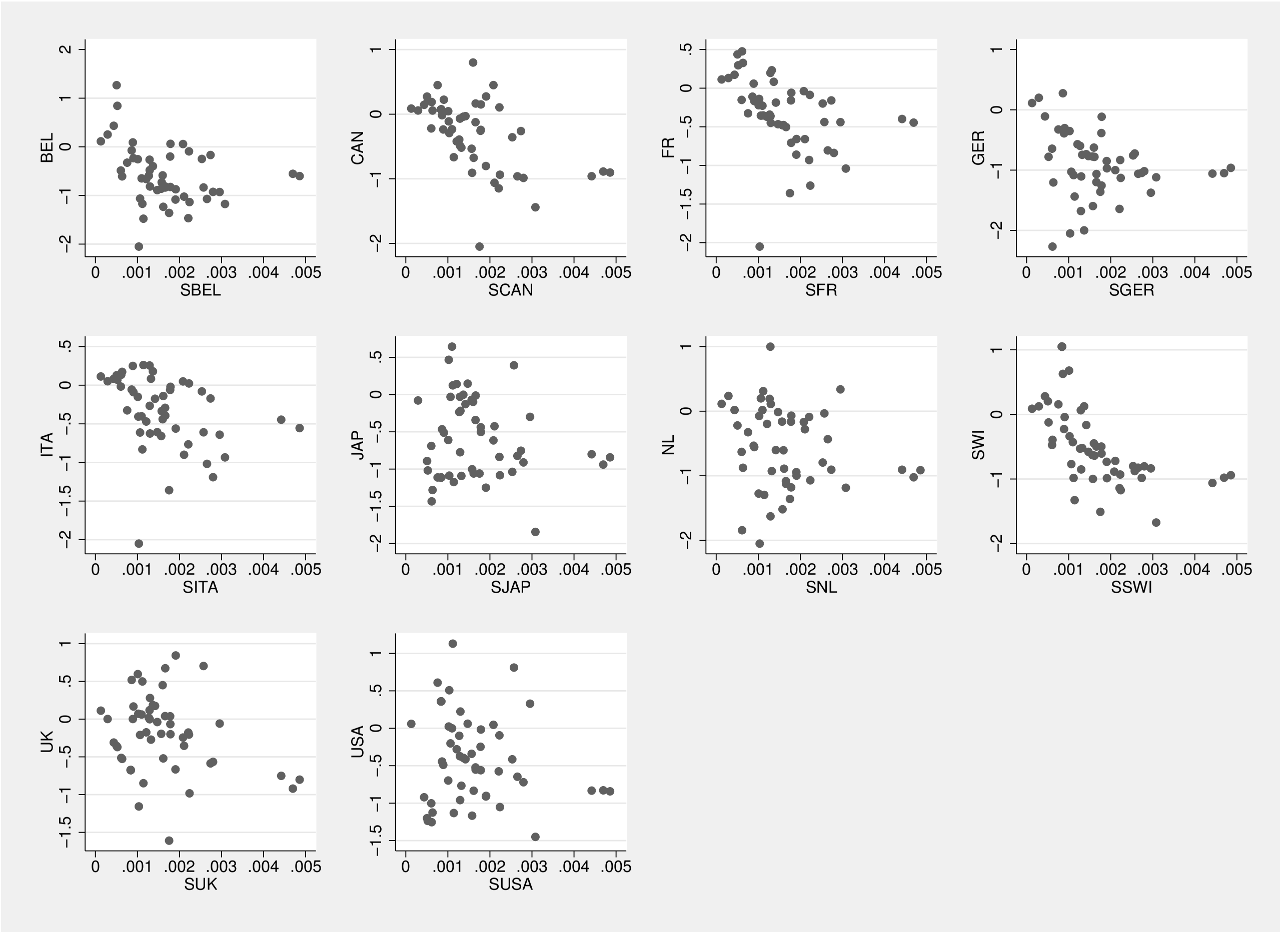

Figure 8: Anchor Country Interest Rate Volatility and Total Bias

Table 2: Regression Results: Effect of Anchor Country Interest Rate Volatility on Slope Coefficient Estimates

	BBEL	BCAN	BFR	BGER	BITA	BJAP	BNL	BSWI	BUK	BUSA	ALL
SBEL	**1,216.17**										
	(2.52)*										
SCAN		503.586									
		0.88									
SFR			558.045								
			1.46								
SGER				**1,111.15**							
				(2.11)*							
SITA					689.036						
					1.41						
SJAP						962.874					
						1.63					
SNL							834.007				
							1.57				
SSWI								**1,533.59**			
								(3.22)**			
SUK									-256.771		
									0.53		
SUSA										**1,954.46**	
										(3.20)**	
ALL											**895.083**
											(5.22)**
Constant	-3.034	-3.792	-1.266	-3.884	-1.111	-4.285	-3.264	-6.123	-1.483	-6.52	-3.44
	(3.39)**	(3.55)**	-1.83	(3.83)**	-1.26	(3.80)**	(3.24)**	(6.67)**	-1.67	(5.67)**	-10.71
Observations	54	54	54	54	54	54	54	54	54	54	540
R-squared	0.11	0.01	0.04	0.08	0.04	0.05	0.05	0.17	0.01	0.16	0.048

Table 3: Regression Results: Effect of Anchor Country Interest Rate Volatility on Total Bias

	BEL	CAN	FR	GER	ITA	JAP	NL	SWI	UK	USA	ALL
SBEL	**-199.23**										
	(-2.33)*										
SCAN		**-294.3**									
		(-4.83)**									
SFR			**-202.79**								
			(-3.07)**								
SGER				-123.57							
				-1.69							
SITA					**-179.39**						
					(-2.74)**						
SJAP						-54.055					
						-0.73					
SNL							-106.37				
							-1.2				
SSWI								**-398.11**			
								(-5.44)**			
SUK									-107.55		
									-1.58		
SUSA										-103.18	
										-1.29	
ALL											**-185.6558**
											(-7.47)**
Constant	-0.251	0.183	-0.008	-0.696	-0.051	-0.533	-0.391	0.235	-0.045	-0.222	-0.159
	-1.54	-1.61	-0.07	(4.77)**	-0.42	(3.76)**	(2.25)*	-1.67	-0.36	-1.47	-3.39
Observations	50	54	50	50	50	54	50	54	54	54	520
R-squared	0.1	0.31	0.16	0.06	0.14	0.01	0.03	0.36	0.05	0.03	0.097

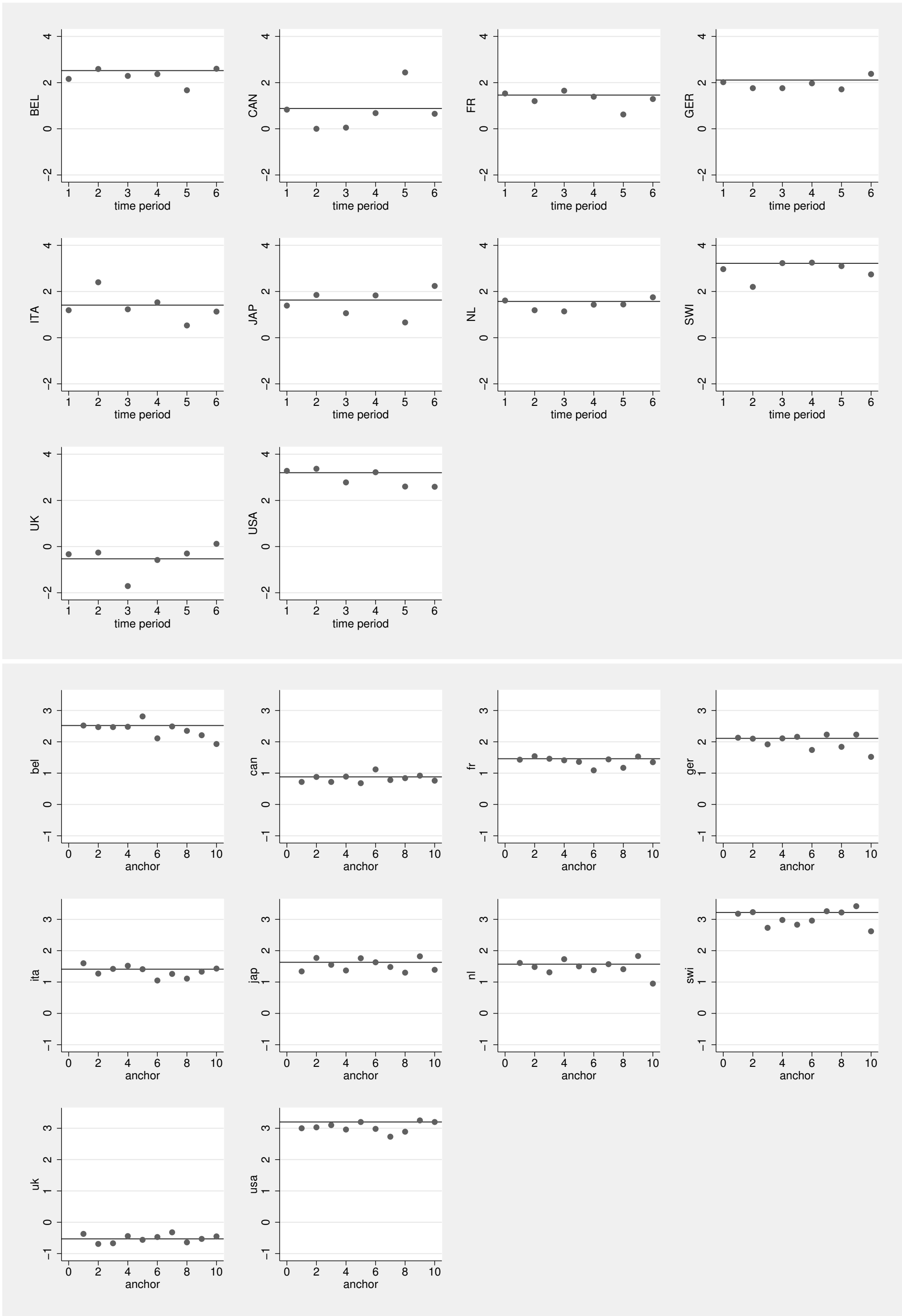

Figure 9: Sensitivity of t-Statistics: Interest Rate Volatility and Slope Coefficient Estimates

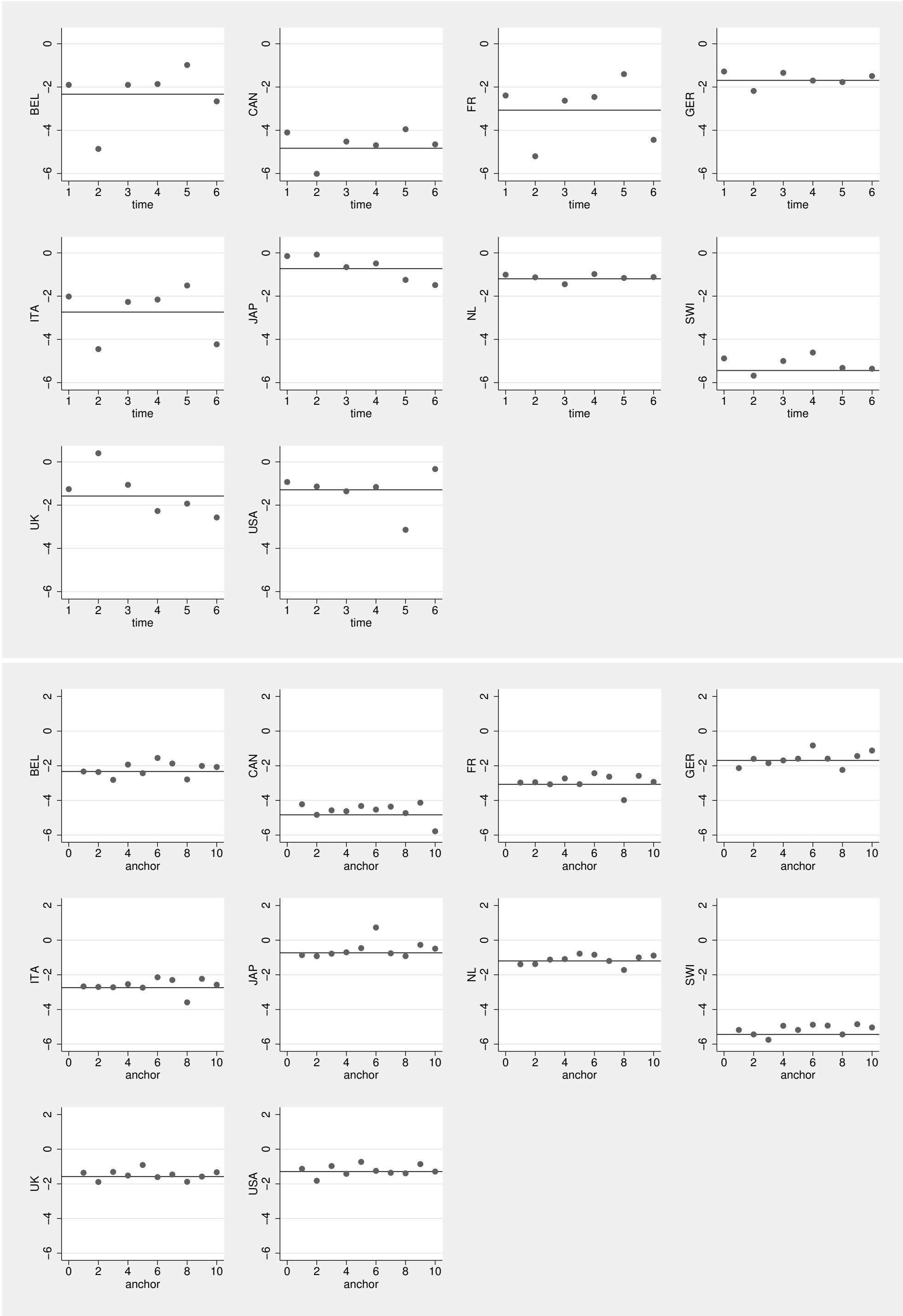

Figure 10: Sensitivity of t-Statistics: Interest Rate Volatility and Total Bias

Table 4: Fixed-Effects Panel Estimations: Interest Rate Volatility and Slope Coefficients

	BBEL	**BCAN**	**BFR**	**BGER**	**BITA**	**BJAP**	**BNL**	**BSWI**	**BUK**	**BUSA**
SBEL	**1,009.25**									
	(2.01)*									
SCAN		396.815								
		0.61								
SFR			522.725							
			1.28							
SGER				764.342						
				1.47						
SITA					790.235					
					1.56					
SJAP						578.851				
						0.93				
SNL							672.653			
							1.3			
SSWI								**1,367.51**		
								(2.68)*		
SUK									-565.046	
									-1.13	
SUSA										**1,679.12**
										(2.47)*
Constant	-2.705	-3.623	-1.211	-3.314	-1.266	-3.658	-3.004	-5.852	-1.002	-6.081
	(2.95)**	(3.03)**	-1.66	(3.34)**	-1.41	(3.10)**	(3.11)**	(6.05)**	-1.1	(4.83)**
Observations	54	54	54	54	54	54	54	54	54	54
Countries	9	9	9	9	9	9	9	9	9	9
R-squared	0.08	0.01	0.04	0.05	0.05	0.02	0.04	0.14	0.03	0.12

Table 5: Fixed-Effects Panel Estimations: Interest Rate Volatility and Total Bias

	BEL	CAN	FR	GER	ITA	JAP	NL	BSWI	UK	USA
SBEL	-127.116									
	-1.46									
SCAN		**-260.895**								
		(-3.91)**								
SFR			**-176.37**							
			(-2.56)*							
SGER				-113.411						
				-1.4						
SITA					**-178.702**					
					(-2.63)*					
SJAP						-24.758				
						-0.35				
SNL							-67.826			
							-0.8			
SSWI								**-376.39**		
								(-5.05)**		
SUK									-70.9	
									-1.02	
SUSA										-107.472
										-1.35
Constant	-0.37	0.13	-0.051	-0.713	-0.052	-0.581	-0.455	0.199	-0.102	-0.216
	(2.27)*	-1.06	-0.4	(4.48)**	-0.42	(4.32)**	(2.80)**	1.41	-0.81	-1.45
Observations	50	54	50	50	50	54	50	54	54	54
Countries	9	9	9	9	9	9	9	9	9	9
R-squared	0.05	0.26	0.14	0.05	0.15	0	0.02	0.36	0.02	0.04