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Appendix to

Taking the Cochrane-Piazzesi Term Structure Model Out of Sample: More Data, Additional Currencies, and FX Implications

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1 A Free Constant Model

The Cochrane and Piazzesi (2005) empirical model in equation (6) in the main paper is inconsistent with the postulated ATSM of Cochrane and Piazzesi (2008) because it constrains the constant terms in each forecasting equation to have the same factor of proportionality as the time varying predictive variable. Examination of equation (14) in the main paper, which is the forecasting equation from the ATSM, shows that the Jensen's inequality terms for different horizons do not scale with the B_{n-1} coefficients of the bond pricing model in the same way that the coefficients on the time-varying risk premiums scale.

To allow for different constant terms for each maturity in the empirical specification, consider the following system of equations that define error terms that are used in GMM:

$$\mathbf{rx}_{t+1} - \boldsymbol{\alpha} = \boldsymbol{\varepsilon}_{1,t+1} \tag{1}$$

$$\overline{\mathbf{fs}}_t - \boldsymbol{\delta} = \boldsymbol{\varepsilon}_{2,t+1} \tag{2}$$

$$(\mathbf{rx}_{t+1} - \boldsymbol{\alpha}) - \mathbf{b}\boldsymbol{\gamma}^\intercal \left(\overline{\mathbf{fs}}_t - \boldsymbol{\delta}\right) = \boldsymbol{\varepsilon}_{3,t+1} \tag{3}$$

The first set of equations (1) specifies $\boldsymbol{\alpha}$ as the vector of unconditional means of the excess returns. The second set of equations (2) specifies $\boldsymbol{\delta}$ as the vector of unconditional means of the average forward spreads where the notation $\overline{\mathbf{fs}}$ used here does not contain a constant term as it does in the main text. The third set of equations (3) specifies that a linear combination of the demeaned forward spreads forecasts the demeaned expected excess returns.

For the orthogonality conditions, we specify that $\boldsymbol{\varepsilon}_{1,t+1}$ and $\boldsymbol{\varepsilon}_{2,t+1}$ are each orthogonal to a constant and that $\boldsymbol{\varepsilon}_{3,t+1}$ is orthogonal to $\overline{\mathbf{fs}}_t$. We estimate this system of orthogonality equations with traditional, two-step GMM, using an identity matrix as the weighting matrix in the first step and the estimated S^{-1} in the second step. We estimate the system of equations simultaneously subject to the constraint that the average of the b_n's equals one. The results are presented in this Appendix in Table 1 for the pre-2004 data and in Table 2 for the post-2003 data. An additional advantage of this specification is that it nests the specification of estimating the sample mean in the out-of-sample forecasting exercise. Examination of the coefficient estimates in these Tables versus the corresponding estimates in the Tables in the main paper indicates that the estimates for the $\mathbf{b}$'s or the $\boldsymbol{\gamma}$'s from this specification do not differ substantively from the estimates in the constrained specification of the main paper.

1.1 Out-of-Sample Forecasts of Restricted Free Constant Model

Table 3 presents the out-of-sample forecast results of the free constant model where the $\boldsymbol{\gamma}$ parameters are constrained to be equal across the nine currencies. The sample for the initial estimation begins in January 1988 for all currencies and ends in December 2003. The out-of-sample period begins in January 2004 and ends in December 2016. Once again, we find that 20 of the 32 R^2's are negative. For GDP, CAD and JPY, the model provides some improvements relative to the forecasts based on the historical means, whereas other currencies perform worse relative to the naive forecast.

2 Out-of-Sample Results for All Maturities and Bonds Denominated in Different Currencies

Figures 1 through 12 plot the differences in the out-of-sample cumulative sums of squared errors from forecasts based on the historical means and the Cochrane-Piazzesi models for excess returns on two-to-five year bonds denominated in different sample currencies. An increase in the cumulative SSE (the solid line) implies that CP model performed better in a given period. The shaded regions show two standard error bands for the SSE. The dotted line shows in-sample results from estimation over the full sample. Note that in some cases the estimated out-of-sample standard error is not positive, in which case no standard error bands are shown.

3 Evolution of the Estimated Parameters of the Models

Figures 13 through 21 present the evolution of the estimated parameters from recursive estimation of the basic model for each of the nine currencies. In general, the $b(k)$ parameter estimates are quite stable for

all currencies. The instability in the estimates of the $\gamma(k)$ parameters is worst for the USD, the AUD, and the NOK and best for the CAD, the JPY, and the SEK. Figures 22 through 30 present the evolution of the parameters from recursive estimation of the free-constant model for each of the nine currencies. Here, the $b(k)$ parameter estimates are slightly more unstable than before, while the estimates of the $\gamma(k)$ parameters appear a bit more stable.

4 Forecasts of Excess Rates of Return in Currency Markets using Alternative Base Currencies

Table 4 presents results corresponding to those of Table 5 of the main paper using different base currencies. In Table 5 we found that the CP forecasting factors generally have no forecasting ability for excess currency returns in the USD base currency regressions whereas the parameter estimates on the interest differentials were generally significant and larger than one for the first sample and insignificant and often negative in the second sample. For the corresponding results in this Appendix, we find that we can only reject the null hypothesis that the CP factors have no forecasting ability at the .10 marginal level of significance in two of the 28 regressions for the first sample. For the second sample, we find that we can reject this null hypothesis in 11 of the 28 regressions, but the evidence of instability is strong as the parameter estimates change sign in 27 of the 56 cases. The parameter estimates on the interest differentials in these alternative base currency regressions also bear a strong resemblance to their USD base currency counterparts. For the first sample, we find that 22 of the 28 parameter estimates on the interest differential are greater than one, although only 8 of the 22 are significantly different from zero. For the second sample, we find that 18 of these 28 parameters are estimated to be less than zero, and only three of the estimates are found to be significantly different from zero.

References

Clark, T. E. and M. W. McCracken (2005). Evaluating direct multistep forecasts. *Econometric Reviews 24*(4), 369–404.

Cochrane, J. H. and M. Piazzesi (2005). Bond risk premia. *American Economic Review 95*(1), 138–160.

Cochrane, J. H. and M. Piazzesi (2008). Decomposing the yield curve. University of Chicago Working Paper.

Table 1: The Single Factor Model with Free Constants (Pre-2004 Data)

The Table reports coefficient estimates for the single factor model with free constants. The errors of the model are defined by these equations:

$$\begin{aligned} \mathbf{rx}_{t_1} - \boldsymbol{\alpha} &= \boldsymbol{\varepsilon}_{1,t+1} \\ \overline{\mathbf{fs}}_t - \boldsymbol{\delta} &= \boldsymbol{\varepsilon}_{2,t+1} \\ (\mathbf{rx}_{t_1} - \boldsymbol{\alpha}) - \mathbf{b}\boldsymbol{\gamma}^{\intercal}\left(\overline{\mathbf{fs}}_t - \boldsymbol{\delta}\right) &= \boldsymbol{\varepsilon}_{3,t+1} \end{aligned}$$

The GMM orthogonality conditions specify that $\boldsymbol{\varepsilon}_{1,t+1}$ and $\boldsymbol{\varepsilon}_{2,t+1}$ are each orthogonal to a constant and that $\boldsymbol{\varepsilon}_{3,t+1}$ is orthogonal to $\overline{\mathbf{fs}}_t$. We estimate this system of orthogonality equations with traditional, two-step GMM subject to the constraint that the average of the b_n's equals one. Standard errors are constructed with 18 Newey-West (1987) lags. The J-stat tests the overidentifying restrictions of the model. The R^2 corresponds to the projection of the average returns on the forward spreads from the first step regression. Standard errors are in parentheses, and p-values are in angled brackets. The sample periods for the dependent variables all end in 2003:12. The samples begin in 1974:12 for the USD, the GBP, and the EUR; in 1989:03 for the CHF; in 1987:03 for the CAD; in 1986:03 for the JPY; in 1988:04 for the AUD; in 1988:03 for the SEK; and in 1999:03 for the NOK.

CUR	α_2	α_3	α_4	α_5	δ_2	δ_3	δ_4	δ_5	
USD1	0.31	0.51	0.87	0.92	0.74	1.12	1.49	1.46	
	(0.23)	(0.43)	(0.61)	(0.74)	(0.09)	(0.16)	(0.19)	(0.19)	
GBP1	0.65	1.13	1.49	1.85	0.18	0.39	0.51	0.59	
	(0.17)	(0.29)	(0.39)	(0.49)	(0.13)	(0.19)	(0.22)	(0.23)	
EUR1	0.73	1.47	2.03	2.46	0.47	0.93	1.24	1.41	
	(0.24)	(0.42)	(0.56)	(0.68)	(0.10)	(0.15)	(0.18)	(0.21)	
CHF1	0.14	0.53	0.91	1.18	−0.28	−0.14	0.09	0.27	
	(0.29)	(0.49)	(0.64)	(0.77)	(0.14)	(0.20)	(0.22)	(0.22)	
CAD1	1.03	1.72	2.23	2.65	0.44	0.67	0.84	0.98	
	(0.20)	(0.38)	(0.54)	(0.70)	(0.11)	(0.17)	(0.20)	(0.22)	
JPY1	0.70	1.50	2.22	2.85	0.26	0.68	1.05	1.34	
	(0.12)	(0.25)	(0.35)	(0.42)	(0.05)	(0.09)	(0.12)	(0.14)	
AUD1	0.93	1.75	2.35	2.82	0.39	0.76	0.94	1.04	
	(0.23)	(0.43)	(0.59)	(0.75)	(0.12)	(0.18)	(0.20)	(0.22)	
SEK1	0.80	1.32	1.75	2.18	0.26	0.44	0.61	0.75	
	(0.22)	(0.45)	(0.66)	(0.85)	(0.05)	(0.07)	(0.07)	(0.07)	
NOK1	−0.06	0.01	0.08	0.13	−0.48	−0.61	−0.62	−0.58	
	(0.07)	(0.14)	(0.20)	(0.26)	(0.02)	(0.04)	(0.05)	(0.06)	

CUR	b_2	b_3	b_4	γ_2	γ_3	γ_4	γ_5	J-stat	R^2
USD1	0.39	0.81	1.25	2.52	2.76	2.90	−5.11	42.88	0.34
	(0.01)	(0.01)	(0.01)	(0.86)	(0.69)	(0.52)	(0.35)	⟨0.00⟩	
GBP1	0.45	0.91	1.24	−5.16	11.49	−6.71	−0.29	31.35	0.06
	(0.03)	(0.02)	(0.02)	(1.95)	(4.43)	(3.71)	(1.16)	⟨0.00⟩	
EUR1	0.39	0.81	1.22	−1.35	−4.41	16.40	−10.06	18.51	0.10
	(0.03)	(0.02)	(0.01)	(2.92)	(8.11)	(10.87)	(5.16)	⟨0.03⟩	
CHF1	0.57	0.92	1.16	−1.56	−9.61	26.12	−14.48	73.23	0.25
	(0.02)	(0.01)	(0.01)	(5.94)	(15.81)	(19.47)	(8.55)	⟨0.00⟩	
CAD1	0.43	0.82	1.19	−0.18	−5.85	19.97	−12.39	41.62	0.17
	(0.02)	(0.02)	(0.01)	(1.89)	(4.43)	(5.40)	(2.51)	⟨0.00⟩	
JPY1	0.40	0.85	1.24	−14.19	18.60	−0.78	−5.74	6.14	0.25
	(0.01)	(0.01)	(0.00)	(1.98)	(2.19)	(0.75)	(0.84)	⟨0.73⟩	
AUD1	0.34	0.74	1.22	−32.99	107.78	−138.79	61.33	30.23	0.12
	(0.03)	(0.02)	(0.01)	(7.34)	(22.68)	(29.37)	(13.12)	⟨0.00⟩	
SEK1	0.28	0.77	1.25	30.32	−68.59	73.52	−29.00	43.75	0.12
	(0.04)	(0.01)	(0.01)	(9.75)	(21.82)	(22.97)	(8.98)	⟨0.00⟩	
NOK1	0.25	0.74	1.26	32.84	−127.21	200.16	−101.56	53.56	0.45
	(0.04)	(0.02)	(0.01)	(5.13)	(17.43)	(24.17)	(11.34)	⟨0.00⟩	

Table 2: The Single Factor Model with Free Constants (Post-2003 Data)

The Table reports coefficient estimates for the single factor model with free constants. The errors of the model are defined by these equations:

$$\begin{aligned} \mathbf{rx}_{t_1} - \boldsymbol{\alpha} &= \boldsymbol{\varepsilon}_{1,t+1} \\ \overline{\mathbf{fs}}_t - \boldsymbol{\delta} &= \boldsymbol{\varepsilon}_{2,t+1} \\ (\mathbf{rx}_{t_1} - \boldsymbol{\alpha}) - \mathbf{b}\boldsymbol{\gamma}^{\intercal}\left(\overline{\mathbf{fs}}_t - \boldsymbol{\delta}\right) &= \boldsymbol{\varepsilon}_{3,t+1} \end{aligned}$$

The GMM orthogonality conditions specify that $\boldsymbol{\varepsilon}_{1,t+1}$ and $\boldsymbol{\varepsilon}_{2,t+1}$ are each orthogonal to a constant and that $\boldsymbol{\varepsilon}_{3,t+1}$ is orthogonal to $\overline{\mathbf{fs}}_t$. We estimate this system of orthogonality equations with traditional, two-step GMM subject to the constraint that the average of the b_n's equals one. Standard errors are constructed with 18 Newey-West (1987) lags. The J-stat tests the overidentifying restrictions of the model. The R^2 corresponds to the projection of the average returns on the forward spreads from the first step regression. Standard errors are in parentheses, and p-values are in angled brackets. The sample periods for the dependent variables all end in 2016:12. The samples begin 2004:12 for all currencies.

CUR	α_2	α_3	α_4	α_5	δ_2	δ_3	δ_4	δ_5	
USD2	0.10	0.62	1.51	2.36	0.64	1.31	2.06	2.60	
	(0.11)	(0.23)	(0.35)	(0.49)	(0.07)	(0.12)	(0.15)	(0.19)	
GBP2	0.52	1.35	2.16	2.89	0.26	0.73	1.14	1.46	
	(0.08)	(0.19)	(0.33)	(0.47)	(0.07)	(0.13)	(0.17)	(0.20)	
EUR2	0.50	1.20	2.00	2.80	0.40	0.84	1.27	1.65	
	(0.07)	(0.13)	(0.20)	(0.26)	(0.04)	(0.08)	(0.10)	(0.12)	
CHF2	0.24	0.73	1.35	1.96	0.14	0.50	0.89	1.21	
	(0.08)	(0.14)	(0.20)	(0.26)	(0.03)	(0.04)	(0.05)	(0.06)	
CAD2	0.58	1.34	2.18	3.03	0.50	0.94	1.28	1.56	
	(0.07)	(0.12)	(0.18)	(0.26)	(0.07)	(0.11)	(0.13)	(0.15)	
JPY2	0.08	0.19	0.42	0.60	0.05	0.15	0.34	0.42	
	(0.01)	(0.02)	(0.04)	(0.05)	(0.02)	(0.03)	(0.04)	(0.05)	
AUD2	0.41	1.15	1.87	2.47	0.17	0.44	0.59	0.60	
	(0.06)	(0.15)	(0.24)	(0.32)	(0.05)	(0.08)	(0.09)	(0.08)	
SEK2	0.64	1.39	2.06	2.61	0.35	0.69	0.93	1.08	
	(0.10)	(0.23)	(0.38)	(0.52)	(0.05)	(0.08)	(0.10)	(0.12)	
NOK2	0.34	0.86	1.44	2.05	0.16	0.37	0.64	0.88	
	(0.07)	(0.15)	(0.23)	(0.32)	(0.04)	(0.08)	(0.10)	(0.12)	

CUR	b_2	b_3	b_4	γ_2	γ_3	γ_4	γ_5	J-stat	R^2
USD2	0.32	0.70	1.22	−10.58	1.27	4.82	0.63	27.35	−1.38
	(0.02)	(0.03)	(0.00)	(2.61)	(1.35)	(1.76)	(0.86)	⟨0.00⟩	
GBP2	0.22	0.68	1.25	−8.40	−5.45	27.09	−15.57	52.69	0.28
	(0.03)	(0.02)	(0.01)	(2.56)	(11.58)	(17.01)	(7.61)	⟨0.00⟩	
EUR2	0.31	0.75	1.23	−20.94	35.32	−24.82	6.50	17.79	0.09
	(0.03)	(0.02)	(0.01)	(6.31)	(13.84)	(13.10)	(4.50)	⟨0.04⟩	
CHF2	0.41	0.84	1.23	−10.39	16.40	−14.38	5.65	23.94	0.38
	(0.01)	(0.02)	(0.01)	(0.92)	(2.65)	(3.76)	(1.88)	⟨0.00⟩	
CAD2	0.45	0.91	1.25	2.34	−13.58	21.68	−10.14	34.80	0.14
	(0.02)	(0.03)	(0.01)	(1.32)	(3.64)	(4.50)	(1.89)	⟨0.00⟩	
JPY2	0.34	0.80	1.23	3.16	−1.55	2.95	−1.99	21.32	0.30
	(0.01)	(0.01)	(0.01)	(0.49)	(0.72)	(0.68)	(0.64)	⟨0.01⟩	
AUD2	0.29	0.82	1.23	3.74	1.37	−4.28	1.46	30.76	0.11
	(0.03)	(0.02)	(0.01)	(0.95)	(0.88)	(0.62)	(0.33)	⟨0.00⟩	
SEK2	0.08	0.53	1.26	15.09	−40.51	47.64	−19.63	17.93	0.13
	(0.05)	(0.06)	(0.01)	(2.61)	(6.92)	(8.32)	(3.55)	⟨0.04⟩	
NOK2	1.93	2.17	0.95	−5.13	7.38	−3.16	−0.55	85.02	0.01
	(1.71)	(1.51)	(0.29)	(6.06)	(8.82)	(4.21)	(0.81)	⟨0.00⟩	

Table 3: Out-of-Sample Forecasts of Excess Bond Returns: Restricted Cochrane-Piazzesi Models vs. Historical Means

The Table reports two statistics that compare the out-of-sample forecasts from recursive estimations of the free constant version of the Cochrane and Piazzesi (2005) model for the excess rates of returns on bonds denominated in different currencies compared to the forecasts based only on the historical mean excess rates of return. The parameters are restricted to be equal across all the currencies. The first statistic is the R^2, which is calculated as one minus the ratio of the mean squared error of the CP forecasts to the mean squared error of the historical mean. The second statistic tests the equality of the forecasts and is the Clark and McCracken (2005) $MSE-F$ statistic. The sample periods for the dependent variables during the initial in-sample estimation all end in 2003:12, which is the end of the Cochrane and Piazzesi (2005) sample. The sample for the initial estimation begins in January 1988 for all currencies. The out-of-sample period begins in January 2004 and ends in December 2016.

	R^2				MSE-F			
CUR	$rx_{t+1}^{(2)}$	$rx_{t+1}^{(3)}$	$rx_{t+1}^{(4)}$	$rx_{t+1}^{(5)}$	$rx_{t+1}^{(2)}$	$rx_{t+1}^{(3)}$	$rx_{t+1}^{(4)}$	$rx_{t+1}^{(5)}$
USD	-0.32	-0.40	-0.34	-0.39	-35.45	-41.56	-37.01	-41.04
GBP	0.02	0.09	0.11	0.11	2.98	13.74	18.42	18.32
EUR	-0.06	-0.04	-0.03	-0.03	-8.81	-5.38	-4.11	-3.61
CHF	-0.10	-0.11	-0.16	-0.19	-13.36	-14.81	-20.37	-23.33
CAD	0.04	0.11	0.14	0.13	6.03	18.69	24.32	21.49
JPY	0.14	0.22	0.25	0.21	24.31	41.65	47.14	37.76
AUD	-0.21	-0.14	-0.11	-0.09	-25.10	-17.62	-13.82	-12.39
SEK	-0.43	-0.35	-0.28	-0.21	-43.50	-37.43	-31.76	-25.49

Table 4: Forecasts of Excess Rates of Return in Currency Markets

The Table presents estimation results for the regression

$$-\Delta s_{ij,t+1} + r_{j,t} - r_{i,t} = \phi_0 + \phi_1 x_{i,t} + \phi_2 x_{j,t} + \phi_3 \left(r_{j,t} - r_{i,t}\right) + \epsilon^s_{ij,t+1},$$

where the dependent variable is the excess currency i rate of return on an annual investment in the money market of currency j. The regressors are the CP factors, the fitted return forecasting variables from the term structure regressions for currencies i and j, and the difference in the one-year yields between currencies j and i. Standard errors are in parentheses, and p-values are in angled brackets. The $\chi^2(2)_{\phi_1,\phi_2=0}$ statistic tests the null hypothesis that ϕ_1 and ϕ_2 equal zero. The $\chi^2(1)_{\phi_3=0}$ and $\chi^2(1)_{\phi_3=1}$ statistics test the null hypothesis that ϕ_3 equals either zero or one, respectively. The results for the first sample period are labeled CUR1, and the dependent variables all end in 2003:12. The first samples begin in 1974:12 for the GBP and the EUR; in 1989:03 for the CHF; in 1987:03 for the CAD; in 1986:03 for the JPY; in 1988:04 for the AUD; in 1988:03 for the SEK; and in 1999:03 for the NOK. The results for the second sample period are labeled CUR2, and the dependent variables all begin in 2004:12 and end in 2016:12.

CUR j	ϕ_0	ϕ_1	ϕ_2	ϕ_3	$\chi^2(2)_{\phi_1,\phi_2=0}$	$\chi^2(1)_{\phi_3=0}$	$\chi^2(1)_{\phi_3=1}$	R^2
Base currency = GBP								
EUR1	−0.41	1.14	2.70	1.94	2.55	7.32	1.71	0.18
	(4.88)	(1.27)	(1.70)	(0.72)	⟨0.28⟩	⟨0.01⟩	⟨0.19⟩	
EUR2	4.39	0.73	−3.67	−1.73	0.92	0.34	0.84	0.08
	(7.52)	(2.22)	(3.97)	(2.98)	⟨0.63⟩	⟨0.56⟩	⟨0.36⟩	
CHF1	−1.84	5.01	−3.31	1.37	2.51	0.43	0.03	0.35
	(9.31)	(3.75)	(2.29)	(2.09)	⟨0.28⟩	⟨0.51⟩	⟨0.86⟩	
CHF2	−2.66	1.56	2.76	0.03	15.88	0.00	0.48	0.14
	(3.38)	(1.18)	(0.95)	(1.40)	⟨0.00⟩	⟨0.98⟩	⟨0.49⟩	
CAD1	0.29	−0.65	0.88	2.69	0.60	1.11	0.44	0.08
	(5.12)	(3.39)	(1.31)	(2.56)	⟨0.74⟩	⟨0.29⟩	⟨0.51⟩	
CAD2	−3.53	3.03	−0.96	−4.90	5.88	13.17	19.09	0.37
	(2.95)	(1.30)	(1.76)	(1.35)	⟨0.05⟩	⟨0.00⟩	⟨0.00⟩	
JPY1	20.51	−0.35	−0.82	4.18	0.18	1.22	0.71	0.12
	(25.46)	(8.41)	(2.48)	(3.78)	⟨0.91⟩	⟨0.27⟩	⟨0.40⟩	
JPY2	−27.40	8.45	12.63	−2.85	17.31	5.41	9.87	0.40
	(7.05)	(2.14)	(4.83)	(1.22)	⟨0.00⟩	⟨0.02⟩	⟨0.00⟩	
AUD1	1.82	1.12	−1.76	0.97	4.33	0.82	0.00	0.08
	(4.99)	(2.00)	(1.21)	(1.07)	⟨0.11⟩	⟨0.37⟩	⟨0.98⟩	
AUD2	2.76	3.02	−0.79	−1.39	2.22	1.01	2.98	0.08
	(4.07)	(2.11)	(1.04)	(1.38)	⟨0.33⟩	⟨0.32⟩	⟨0.08⟩	
SEK1	−6.24	1.50	1.97	1.25	2.23	0.79	0.03	0.17
	(5.37)	(1.55)	(1.82)	(1.40)	⟨0.33⟩	⟨0.37⟩	⟨0.86⟩	
SEK2	−1.48	0.25	0.78	−0.65	0.16	0.19	1.21	−0.01
	(4.80)	(1.48)	(1.97)	(1.50)	⟨0.92⟩	⟨0.66⟩	⟨0.27⟩	
NOK1	−1.19	1.19	0.49	2.15	1.08	1.92	0.55	0.22
	(7.89)	(6.47)	(1.28)	(1.55)	⟨0.58⟩	⟨0.17⟩	⟨0.46⟩	
NOK2	−2.24	0.01	3.17	−1.35	0.39	0.59	1.80	0.02
	(7.77)	(1.54)	(5.61)	(1.75)	⟨0.82⟩	⟨0.44⟩	⟨0.18⟩	

CUR j	ϕ_0	ϕ_1	ϕ_2	ϕ_3	$\chi^2(2)_{\phi_1,\phi_2=0}$	$\chi^2(1)_{\phi_3=0}$	$\chi^2(1)_{\phi_3=1}$	R^2
Base currency = EUR								
CHF1	3.21	−1.22	−0.15	1.81	0.59	0.95	0.19	0.10
	(3.96)	(1.83)	(0.74)	(1.85)	⟨0.75⟩	⟨0.33⟩	⟨0.66⟩	
CHF2	−0.22	2.08	1.72	3.84	11.64	6.23	3.41	0.29
	(3.40)	(2.17)	(0.60)	(1.54)	⟨0.00⟩	⟨0.01⟩	⟨0.06⟩	
CAD1	−3.62	−2.91	1.57	3.71	2.25	15.85	8.47	0.24
	(7.49)	(5.33)	(1.09)	(0.93)	⟨0.33⟩	⟨0.00⟩	⟨0.00⟩	
CAD2	−3.38	3.99	−0.56	−2.93	0.81	0.92	1.66	0.15
	(6.12)	(4.51)	(2.10)	(3.05)	⟨0.67⟩	⟨0.34⟩	⟨0.20⟩	
JPY1	12.67	−4.73	0.64	3.34	1.57	3.78	1.86	0.09
	(9.49)	(3.77)	(1.43)	(1.72)	⟨0.46⟩	⟨0.05⟩	⟨0.17⟩	
JPY2	−16.10	5.69	11.56	0.24	12.67	0.02	0.16	0.12
	(14.65)	(6.09)	(4.29)	(1.89)	⟨0.00⟩	⟨0.90⟩	⟨0.69⟩	
AUD1	4.28	−0.06	−2.52	1.04	3.44	0.52	0.00	0.17
	(5.34)	(6.52)	(1.51)	(1.44)	⟨0.18⟩	⟨0.47⟩	⟨0.98⟩	
AUD2	2.72	3.22	−0.45	−1.44	0.13	0.03	0.08	0.01
	(8.48)	(11.35)	(5.37)	(8.40)	⟨0.94⟩	⟨0.86⟩	⟨0.77⟩	
SEK1	−6.08	3.25	−0.00	1.10	0.50	1.57	0.01	0.19
	(5.72)	(4.71)	(1.88)	(0.88)	⟨0.78⟩	⟨0.21⟩	⟨0.91⟩	
SEK2	−4.36	2.99	−0.30	−1.82	0.49	0.29	0.69	0.09
	(8.05)	(5.37)	(1.28)	(3.39)	⟨0.78⟩	⟨0.59⟩	⟨0.41⟩	
NOK1	7.93	−2.52	−1.04	−0.65	2.55	0.22	1.45	0.25
	(8.76)	(4.54)	(0.65)	(1.37)	⟨0.28⟩	⟨0.64⟩	⟨0.23⟩	
NOK2	−2.94	2.18	1.89	−2.92	0.37	1.70	3.07	0.12
	(8.93)	(3.99)	(4.18)	(2.24)	⟨0.83⟩	⟨0.19⟩	⟨0.08⟩	
Base currency = CHF								
CAD1	−13.39	1.27	1.24	4.47	2.02	19.88	11.97	0.29
	(2.70)	(1.43)	(1.28)	(1.00)	⟨0.36⟩	⟨0.00⟩	⟨0.00⟩	
CAD2	0.02	0.95	−3.64	2.94	3.95	0.49	0.21	0.13
	(12.56)	(2.99)	(3.42)	(4.20)	⟨0.14⟩	⟨0.48⟩	⟨0.64⟩	
JPY1	4.49	−0.78	0.67	4.28	0.26	1.84	1.08	0.06
	(6.71)	(2.25)	(1.80)	(3.16)	⟨0.88⟩	⟨0.17⟩	⟨0.30⟩	
JPY2	−10.44	4.62	6.58	1.18	22.82	0.12	0.00	0.18
	(4.96)	(1.19)	(5.25)	(3.39)	⟨0.00⟩	⟨0.73⟩	⟨0.96⟩	
AUD1	−0.35	2.03	−1.94	1.23	5.26	2.60	0.09	0.19
	(4.98)	(1.45)	(1.41)	(0.76)	⟨0.07⟩	⟨0.11⟩	⟨0.76⟩	
AUD2	−5.22	−1.67	−2.68	3.27	0.80	2.20	1.06	0.06
	(9.28)	(2.27)	(3.64)	(2.21)	⟨0.67⟩	⟨0.14⟩	⟨0.30⟩	
SEK1	−9.69	1.99	1.24	2.20	3.39	4.77	1.42	0.28
	(4.86)	(1.18)	(1.10)	(1.01)	⟨0.18⟩	⟨0.03⟩	⟨0.23⟩	
SEK2	1.04	−3.32	−0.90	1.84	6.55	0.28	0.06	0.13
	(5.35)	(1.42)	(1.46)	(3.47)	⟨0.04⟩	⟨0.60⟩	⟨0.81⟩	
NOK1	−0.86	−0.65	−0.81	1.27	19.25	1.09	0.05	0.20
	(5.88)	(1.41)	(0.61)	(1.22)	⟨0.00⟩	⟨0.30⟩	⟨0.83⟩	
NOK2	2.66	−1.75	−0.07	−1.68	0.37	0.08	0.19	0.04
	(10.59)	(2.99)	(3.49)	(6.11)	⟨0.83⟩	⟨0.78⟩	⟨0.66⟩	

CUR j	ϕ_0	ϕ_1	ϕ_2	ϕ_3	$\chi^2(2)_{\phi_1,\phi_2=0}$	$\chi^2(1)_{\phi_3=0}$	$\chi^2(1)_{\phi_3=1}$	R^2
Base currency = CAD								
JPY1	27.08	−0.87	−0.98	6.28	1.38	22.22	15.71	0.41
	(6.67)	(1.08)	(1.33)	(1.33)	⟨0.50⟩	⟨0.00⟩	⟨0.00⟩	
JPY2	−8.60	2.14	12.44	1.88	9.81	0.30	0.07	0.16
	(9.18)	(4.42)	(8.57)	(3.42)	⟨0.01⟩	⟨0.58⟩	⟨0.80⟩	
AUD1	3.13	−1.64	0.21	0.13	4.05	0.02	0.67	0.10
	(5.16)	(1.01)	(1.15)	(1.06)	⟨0.13⟩	⟨0.90⟩	⟨0.41⟩	
AUD2	−1.81	6.09	−1.33	−1.41	14.89	0.88	2.58	0.34
	(4.44)	(1.70)	(0.82)	(1.50)	⟨0.00⟩	⟨0.35⟩	⟨0.11⟩	
SEK1	0.84	−0.64	−0.41	0.52	0.30	0.09	0.08	0.00
	(3.94)	(1.30)	(1.43)	(1.76)	⟨0.86⟩	⟨0.77⟩	⟨0.78⟩	
SEK2	−2.16	3.07	−2.50	−1.92	3.85	2.06	4.77	0.15
	(7.07)	(2.02)	(2.78)	(1.34)	⟨0.15⟩	⟨0.15⟩	⟨0.03⟩	
NOK1	−16.62	5.43	0.27	3.28	7.94	1.85	0.89	0.56
	(13.30)	(3.68)	(1.45)	(2.41)	⟨0.02⟩	⟨0.17⟩	⟨0.34⟩	
NOK2	−4.59	1.94	1.08	−1.16	0.75	0.12	0.41	0.02
	(10.47)	(3.64)	(5.87)	(3.37)	⟨0.69⟩	⟨0.73⟩	⟨0.52⟩	
Base currency = JPY								
AUD1	−7.62	0.54	−2.77	2.96	5.06	20.59	9.03	0.38
	(6.52)	(2.02)	(1.25)	(0.65)	⟨0.08⟩	⟨0.00⟩	⟨0.00⟩	
AUD2	10.12	−4.63	−5.64	0.62	5.29	0.11	0.04	0.14
	(7.71)	(5.06)	(2.46)	(1.86)	⟨0.07⟩	⟨0.74⟩	⟨0.84⟩	
SEK1	−2.75	0.53	1.99	0.25	1.00	0.01	0.05	0.02
	(18.28)	(2.38)	(2.02)	(3.47)	⟨0.61⟩	⟨0.94⟩	⟨0.83⟩	
SEK2	16.91	−4.93	−6.25	−2.33	9.88	0.66	1.35	0.16
	(5.88)	(3.32)	(2.34)	(2.87)	⟨0.01⟩	⟨0.42⟩	⟨0.25⟩	
NOK1	−59.23	−3.13	0.50	10.99	5.07	19.23	15.89	0.45
	(12.86)	(1.40)	(1.93)	(2.51)	⟨0.08⟩	⟨0.00⟩	⟨0.00⟩	
NOK2	14.88	−5.14	−4.92	−2.93	2.48	0.87	1.57	0.08
	(7.94)	(6.78)	(3.36)	(3.14)	⟨0.29⟩	⟨0.35⟩	⟨0.21⟩	
Base currency = AUD								
SEK1	−5.96	1.80	0.51	−1.14	2.17	1.14	4.03	0.08
	(4.50)	(1.22)	(1.56)	(1.07)	⟨0.34⟩	⟨0.29⟩	⟨0.04⟩	
SEK2	2.37	0.00	−2.49	0.80	1.93	0.21	0.01	0.05
	(8.04)	(2.93)	(2.11)	(1.73)	⟨0.38⟩	⟨0.65⟩	⟨0.91⟩	
NOK1	−3.33	2.27	−0.87	0.73	0.35	0.11	0.02	0.03
	(7.36)	(3.97)	(1.76)	(2.15)	⟨0.84⟩	⟨0.73⟩	⟨0.90⟩	
NOK2	−3.63	−0.51	−1.62	−1.22	0.14	1.19	3.94	0.04
	(8.65)	(3.43)	(4.58)	(1.12)	⟨0.93⟩	⟨0.28⟩	⟨0.05⟩	
Base currency = SEK								
NOK1	−5.58	4.63	−0.58	1.06	2.68	0.28	0.00	0.19
	(6.88)	(3.59)	(1.50)	(2.02)	⟨0.26⟩	⟨0.60⟩	⟨0.98⟩	
NOK2	−1.23	1.60	0.73	−2.70	2.78	4.31	8.10	0.12
	(4.69)	(0.97)	(2.91)	(1.30)	⟨0.25⟩	⟨0.04⟩	⟨0.00⟩	

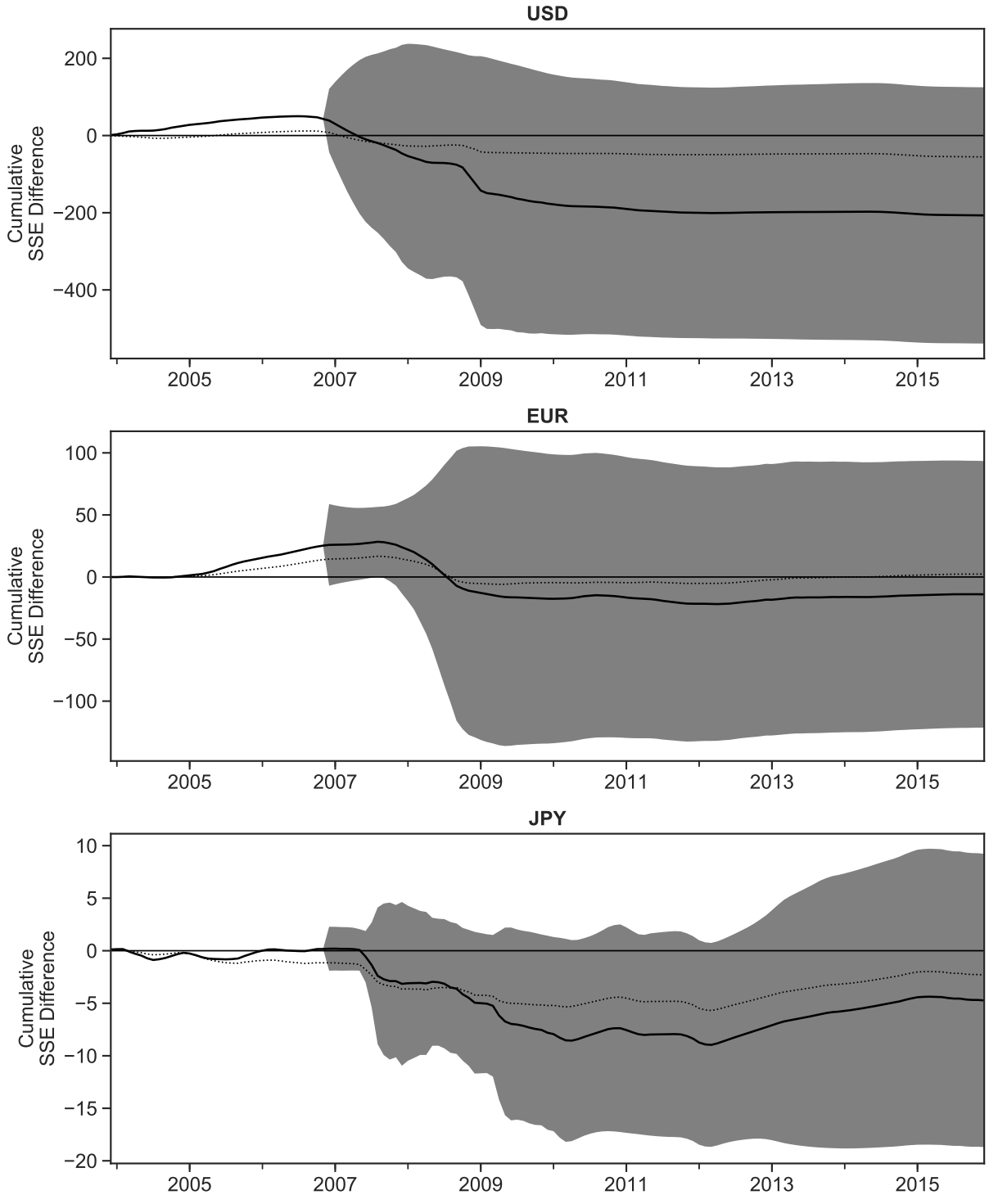

Figure 1: Out-of-Sample Results: 2-year bonds

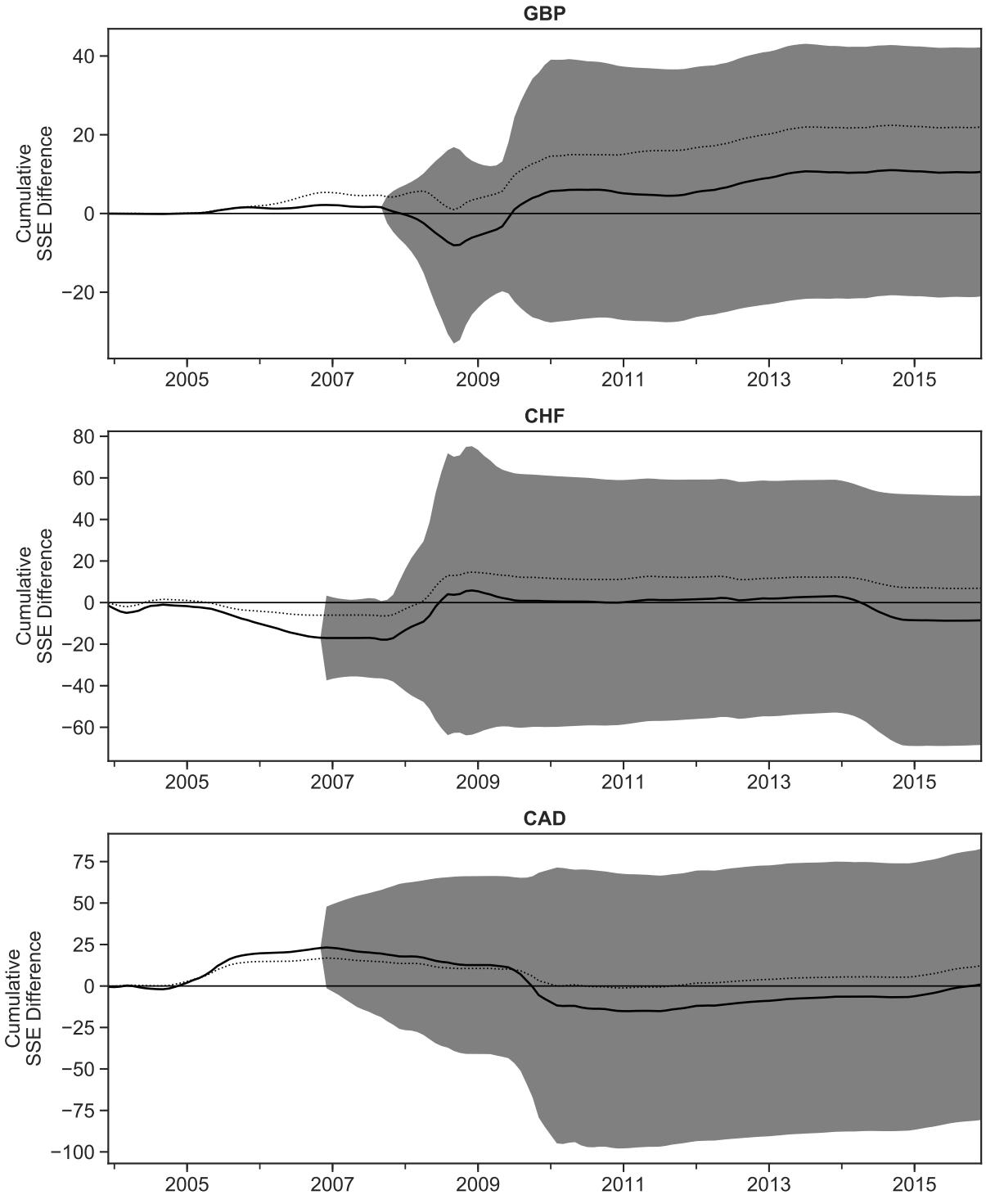

Figure 2: Out-of-Sample Results: 2-year bonds

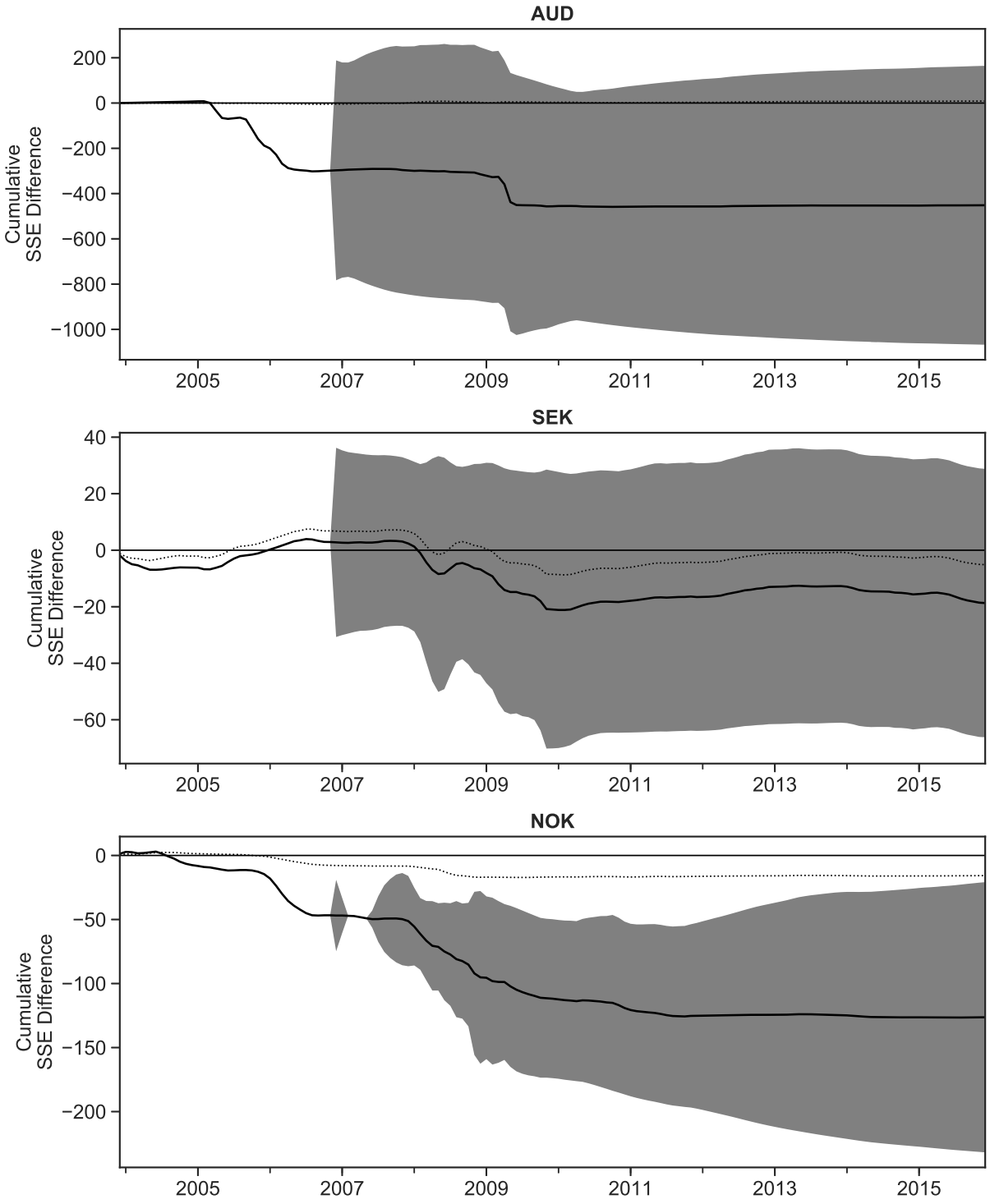

Figure 3: Out-of-Sample Results: 2-year bonds

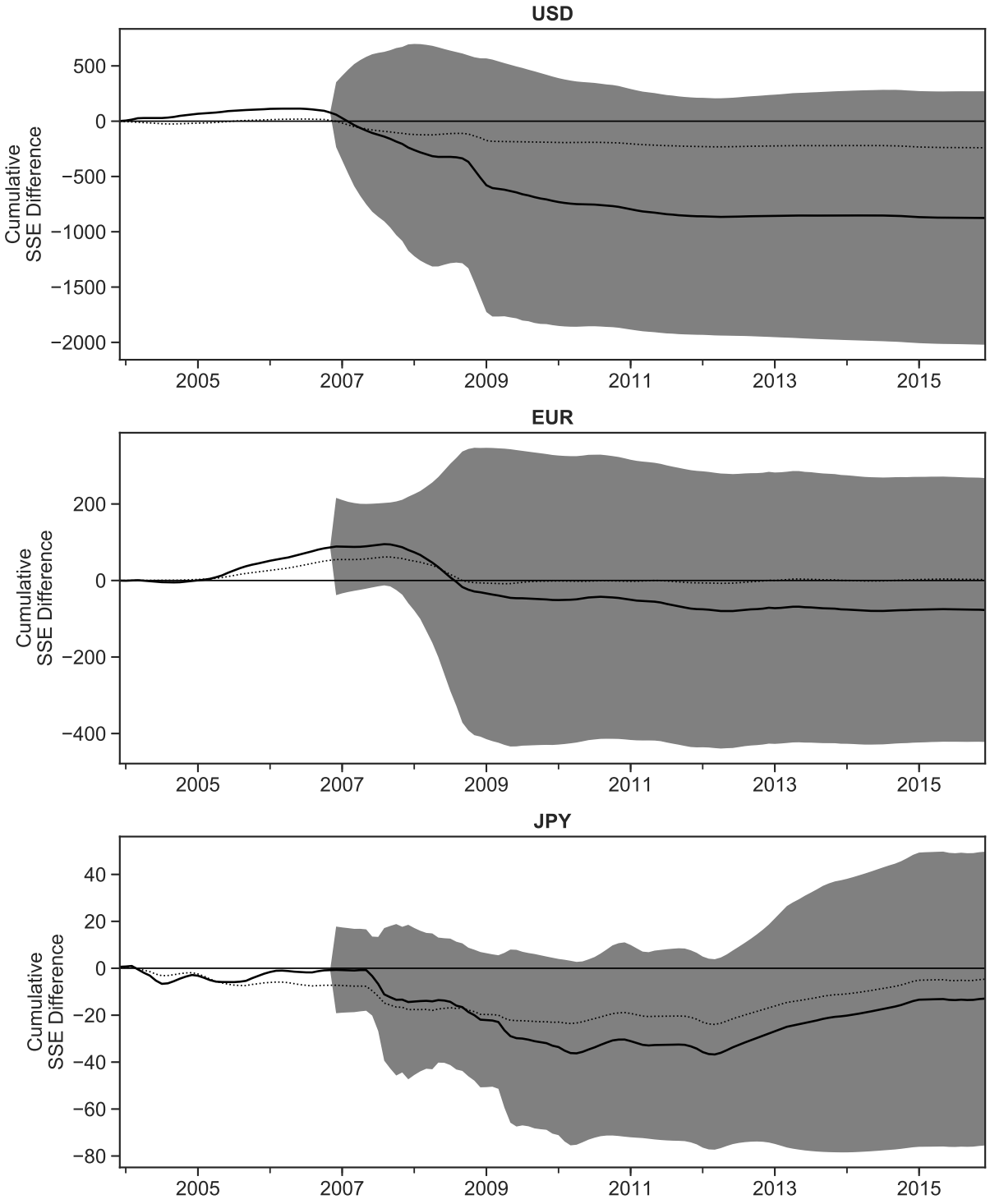

Figure 4: Out-of-Sample Results: 3-year bonds

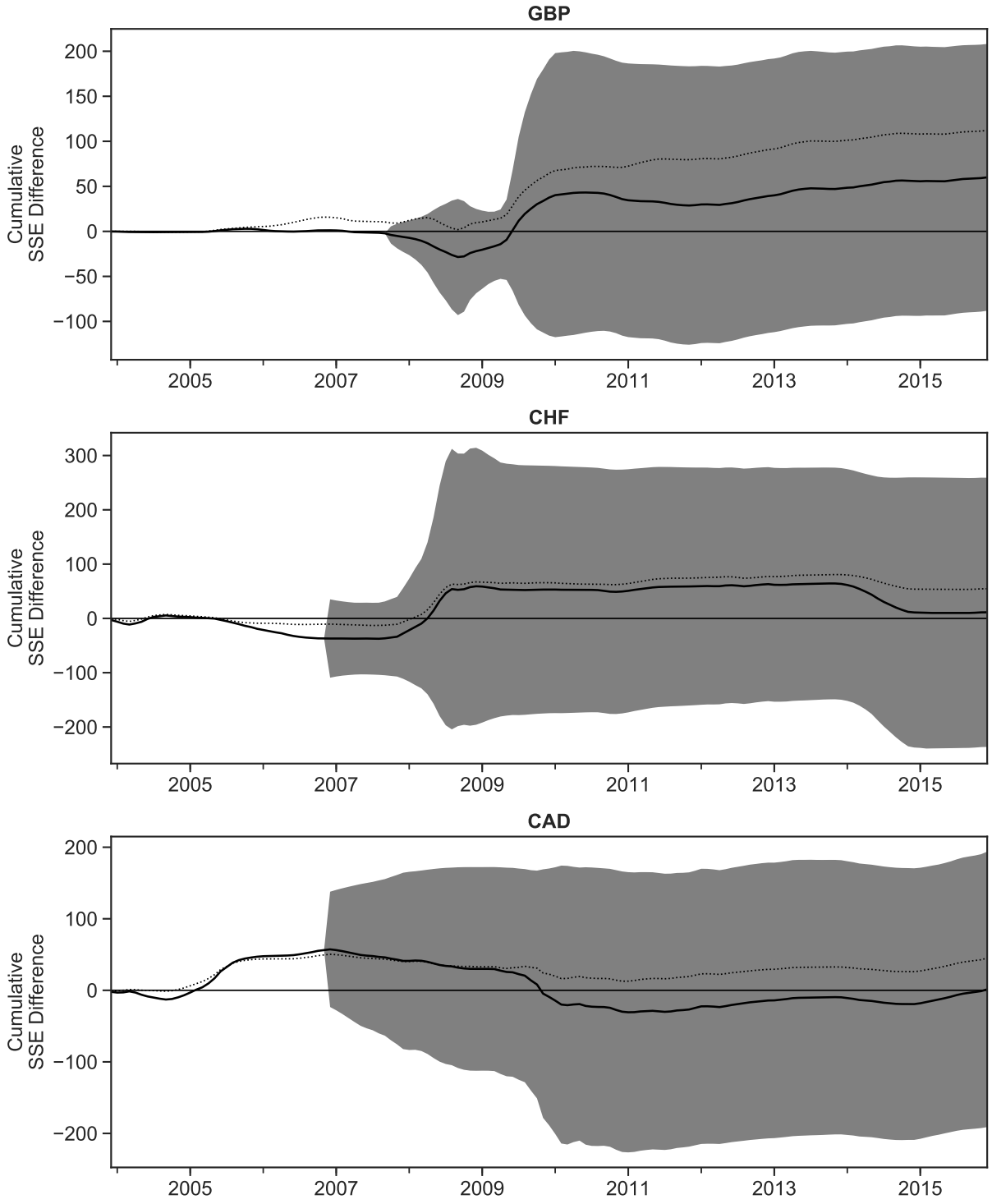

Figure 5: Out-of-Sample Results: 3-year bonds

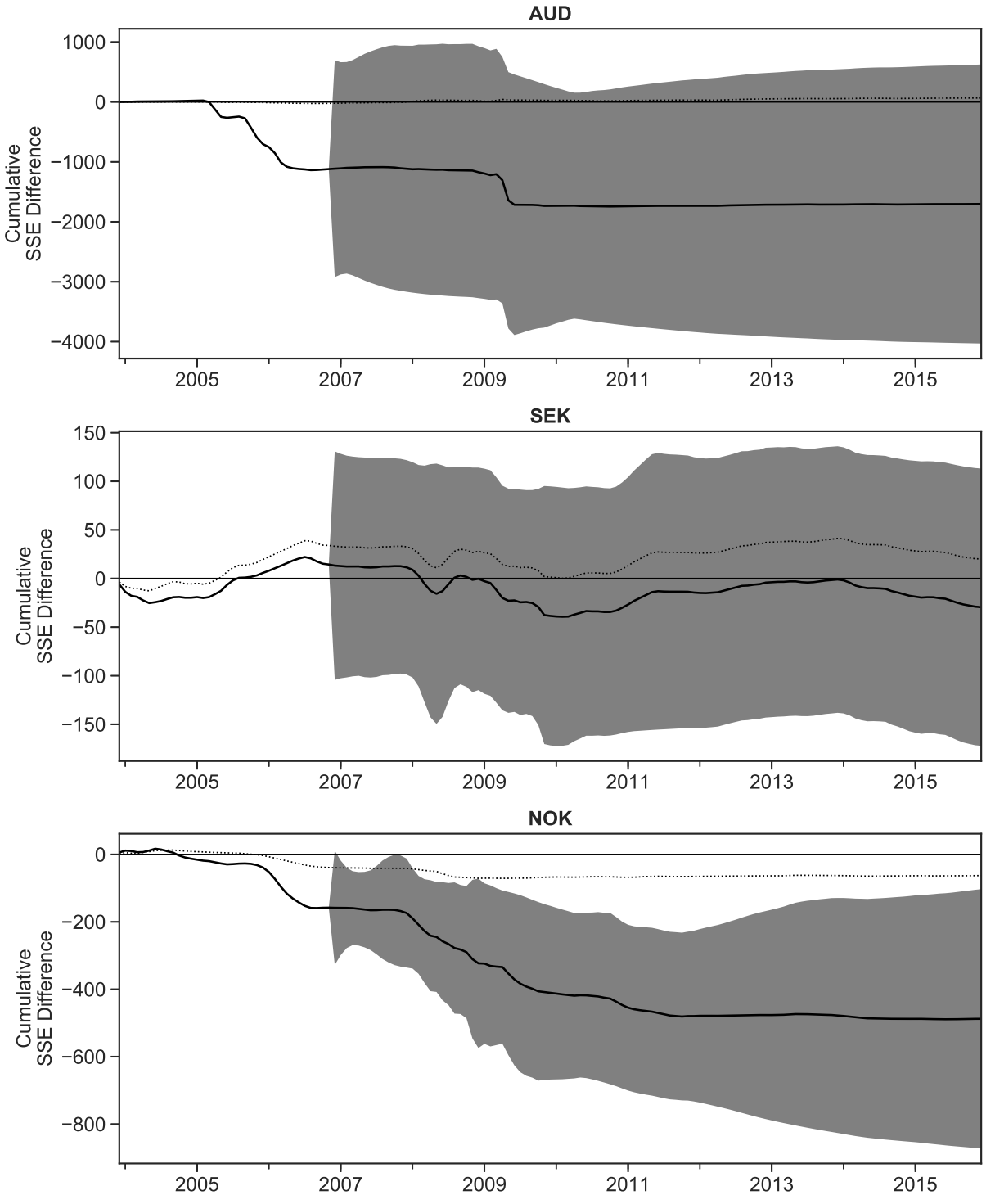

Figure 6: Out-of-Sample Results: 3-year bonds

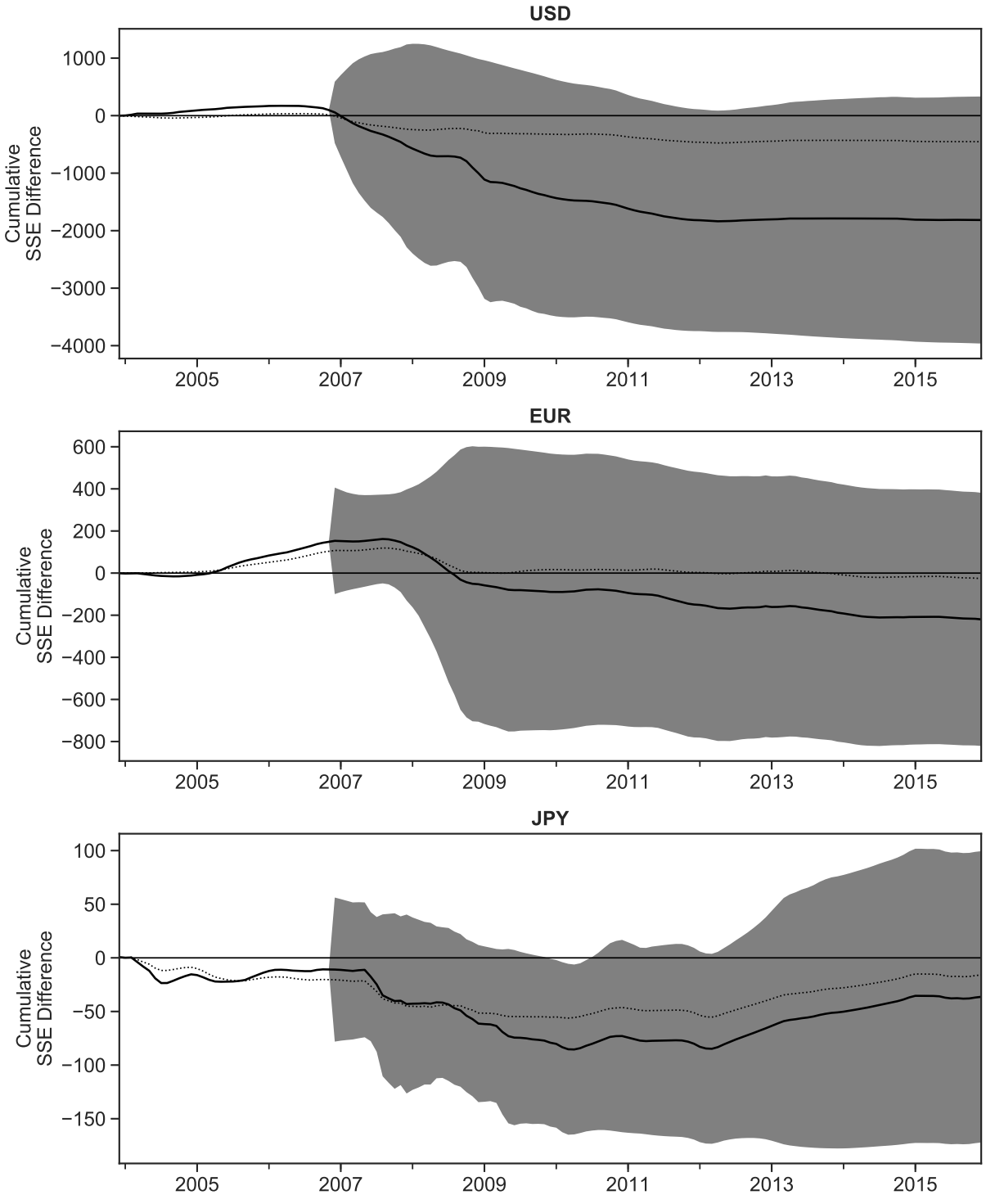

Figure 7: Out-of-Sample Results: 4-year bonds

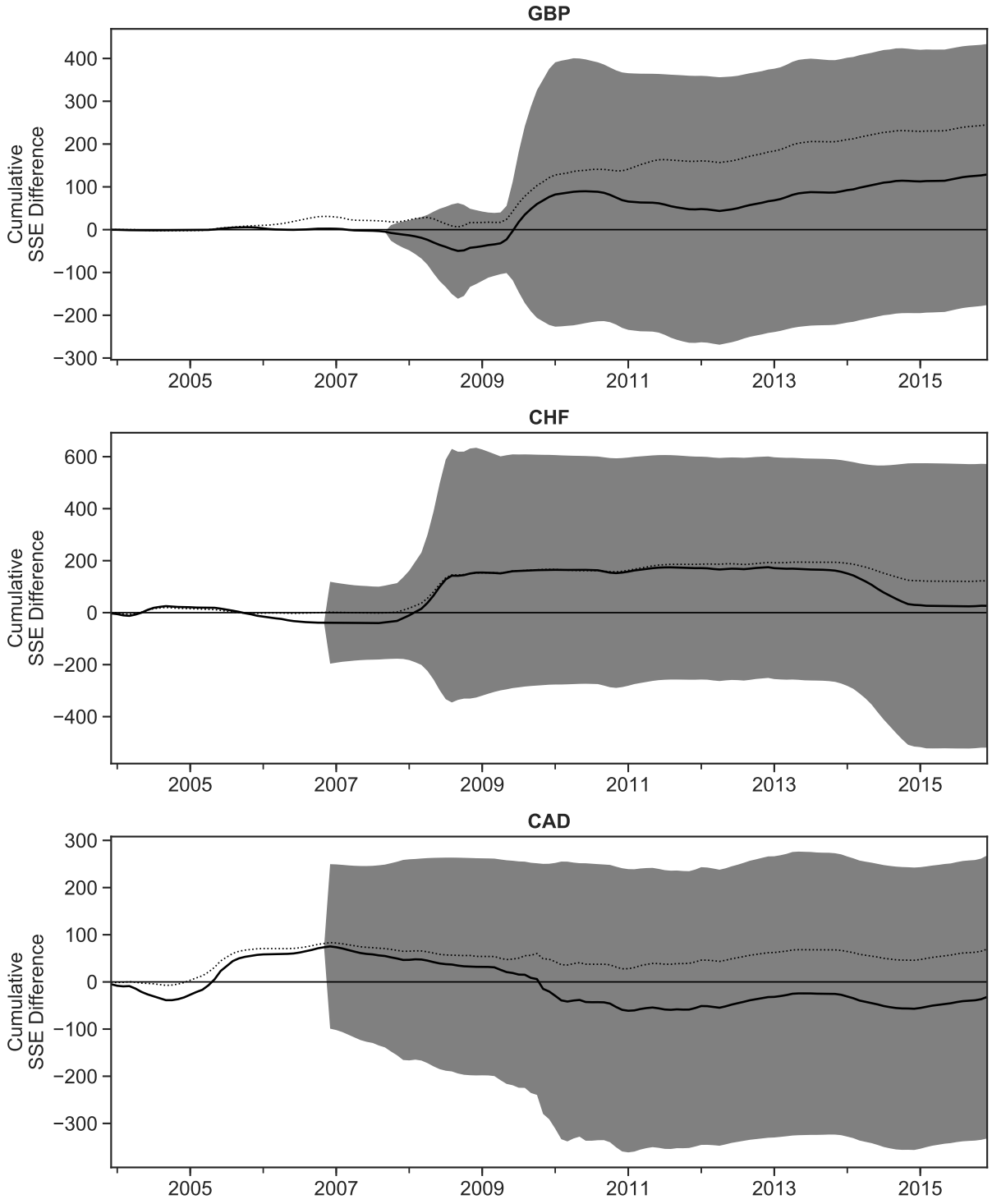

Figure 8: Out-of-Sample Results: 4-year bonds

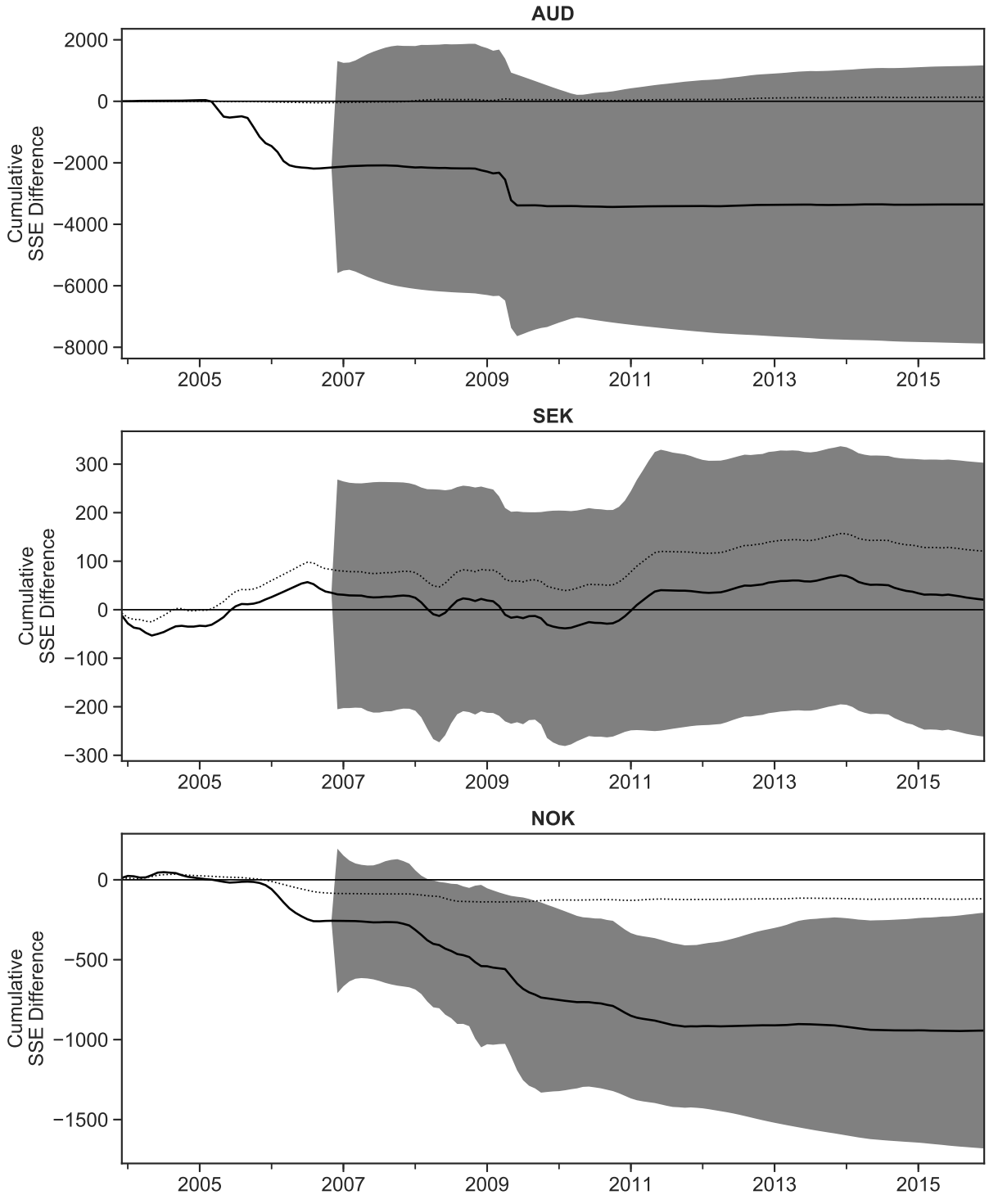

Figure 9: Out-of-Sample Results: 4-year bonds

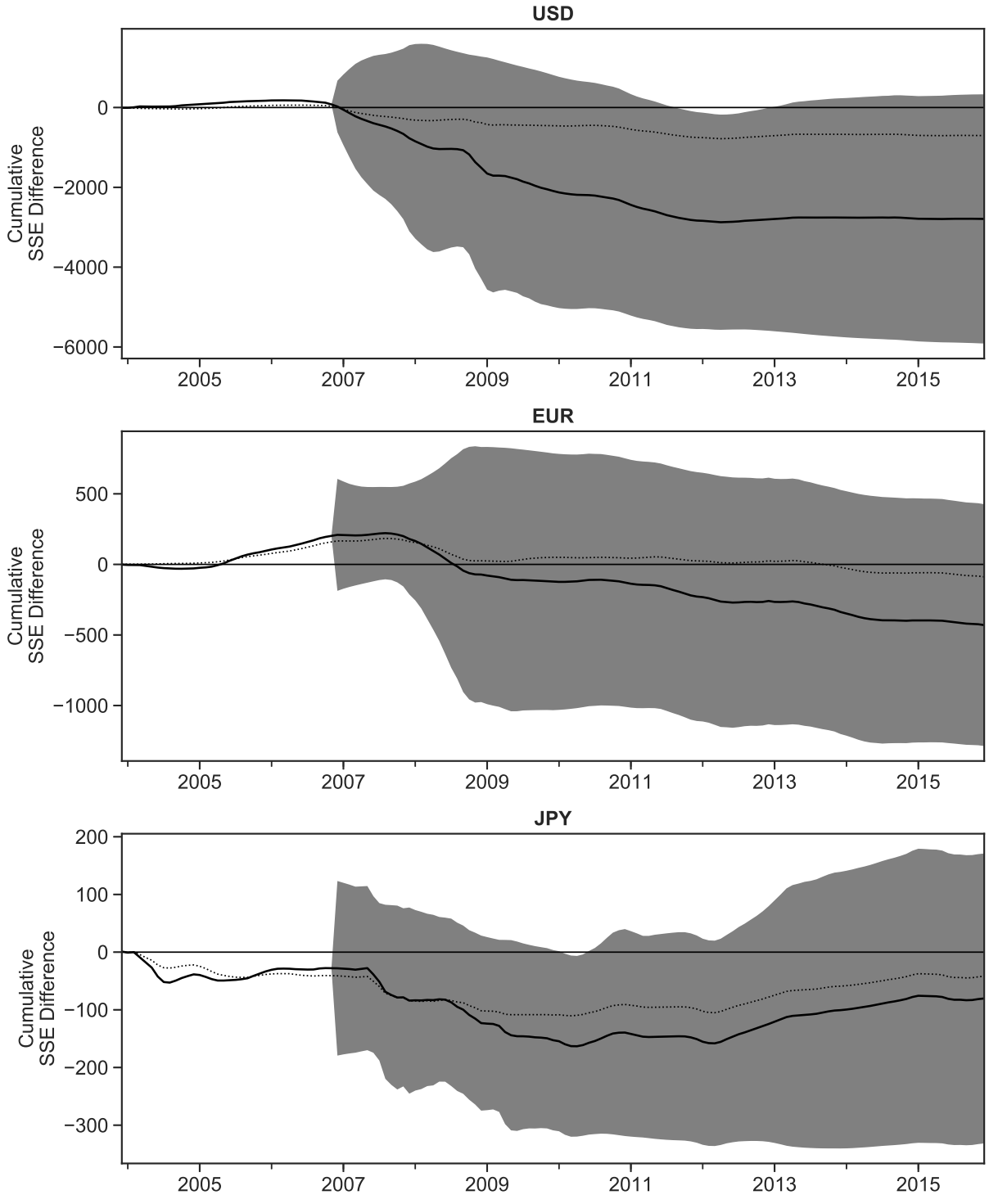

Figure 10: Out-of-Sample Results: 5-year bonds

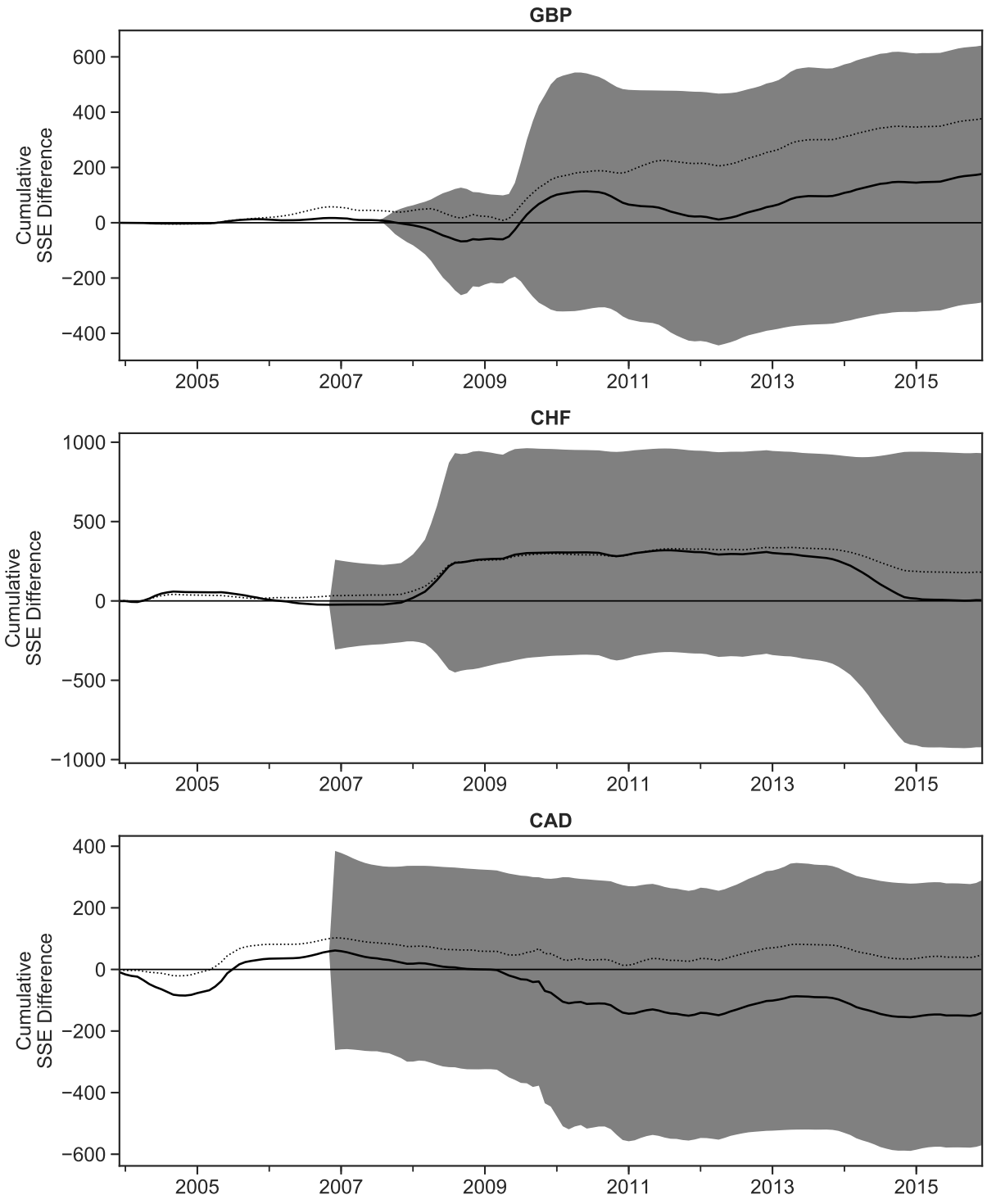

Figure 11: Out-of-Sample Results: 5-year bonds

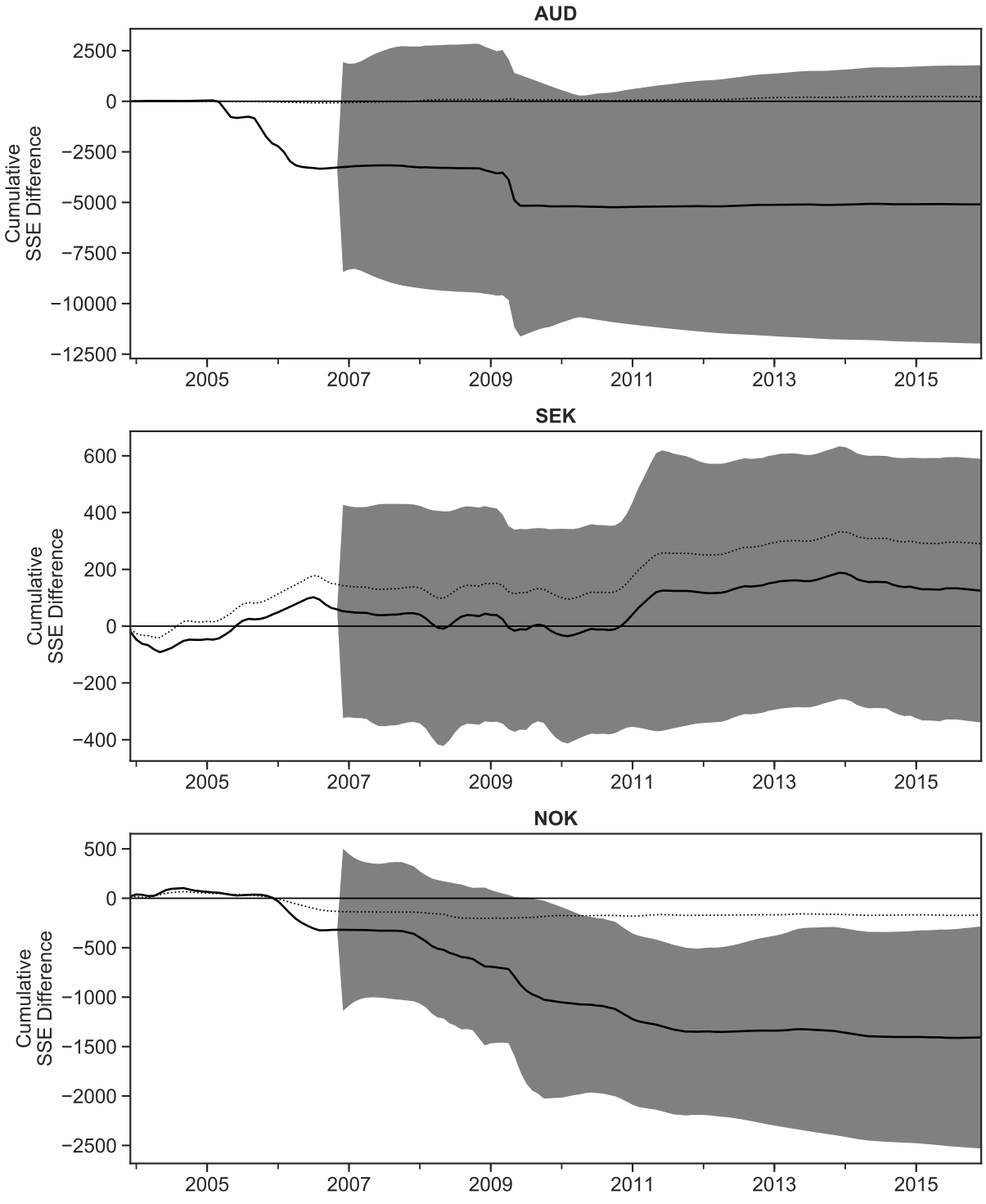

Figure 12: Out-of-Sample Results: 5-year bonds

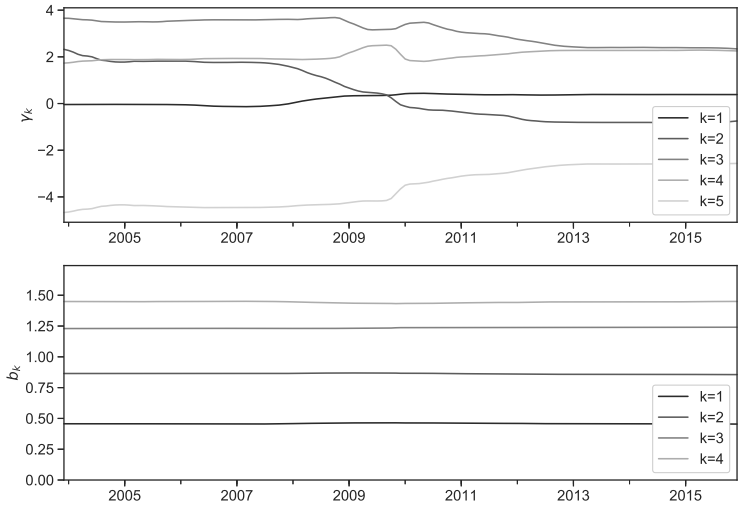

Figure 13: Evolution of parameters in the Basic Model (USD)

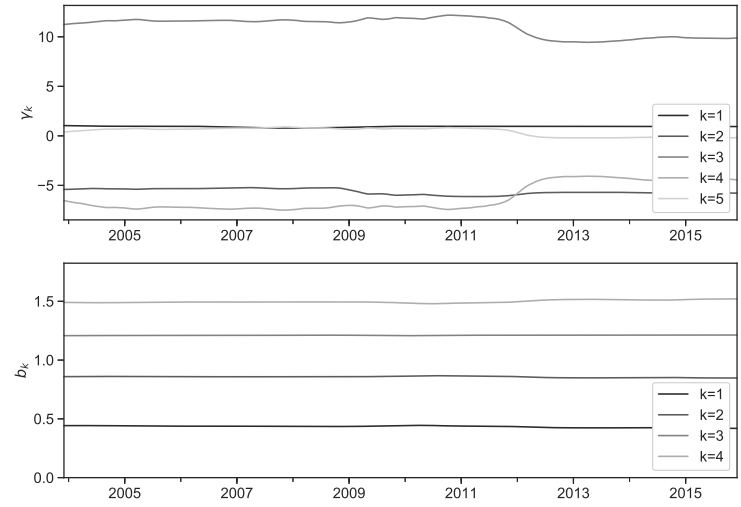

Figure 14: Evolution of parameters in the Basic Model (GBP)

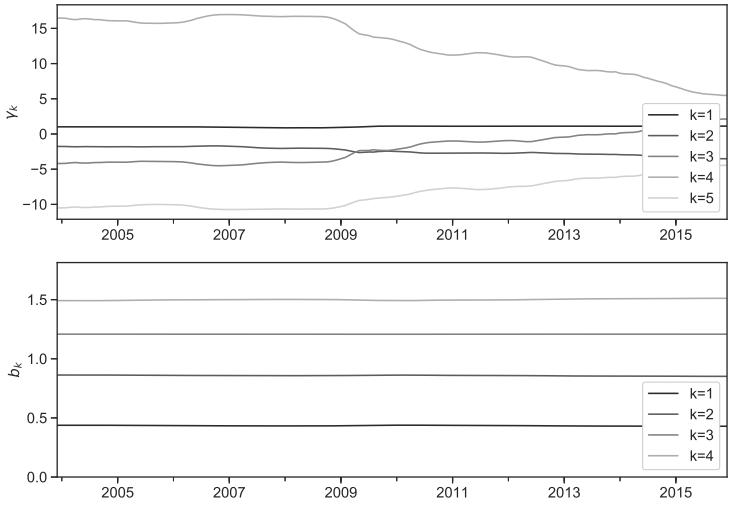

Figure 15: Evolution of parameters in the Basic Model (EUR)

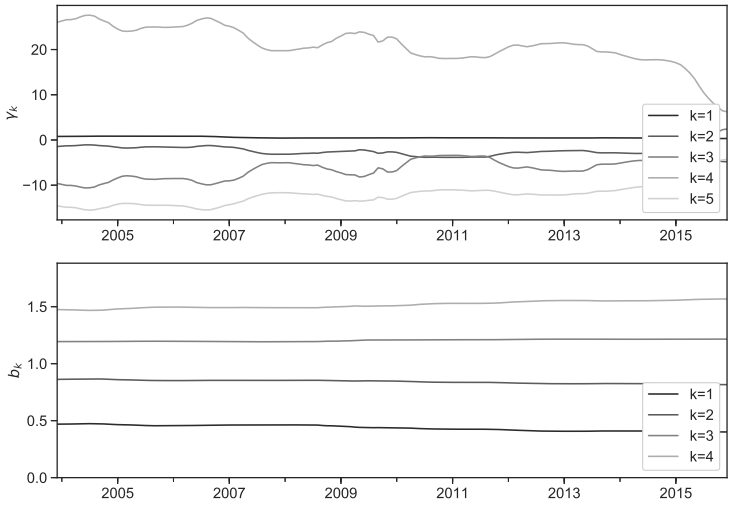

Figure 16: Evolution of parameters in the Basic Model (CHF)

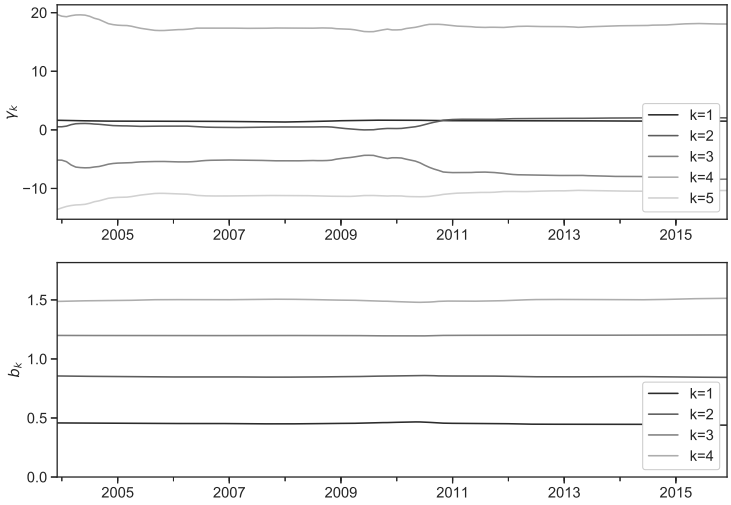

Figure 17: Evolution of parameters in the Basic Model (CAD)

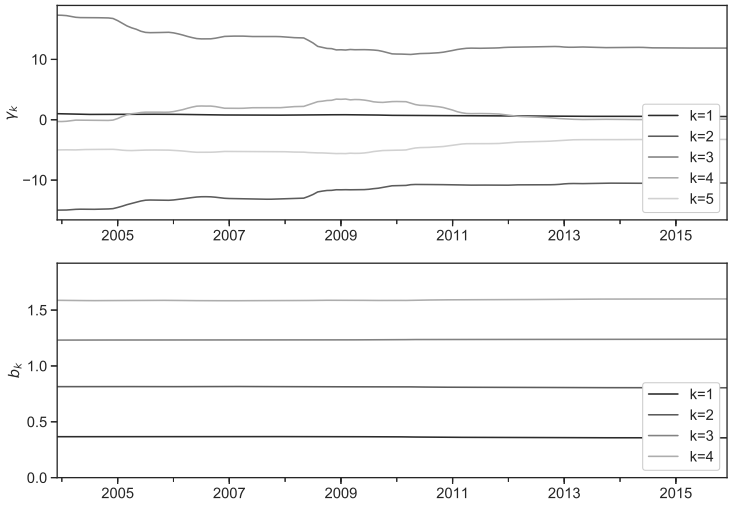

Figure 18: Evolution of parameters in the Basic Model (JPY)

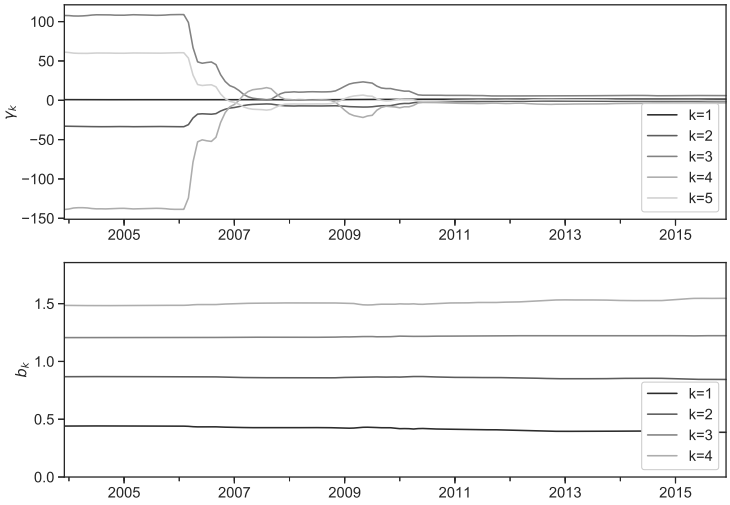

Figure 19: Evolution of parameters in the Basic Model (AUD)

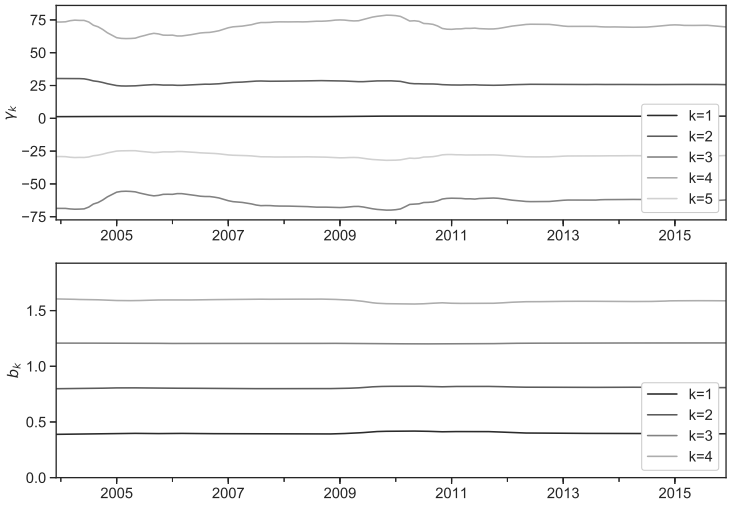

Figure 20: Evolution of parameters in the Basic Model (SEK)

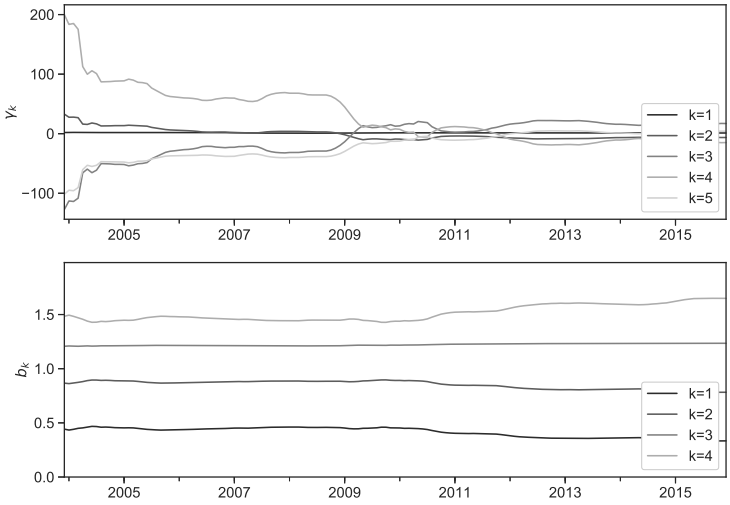

Figure 21: Evolution of parameters in the Basic Model (NOK)

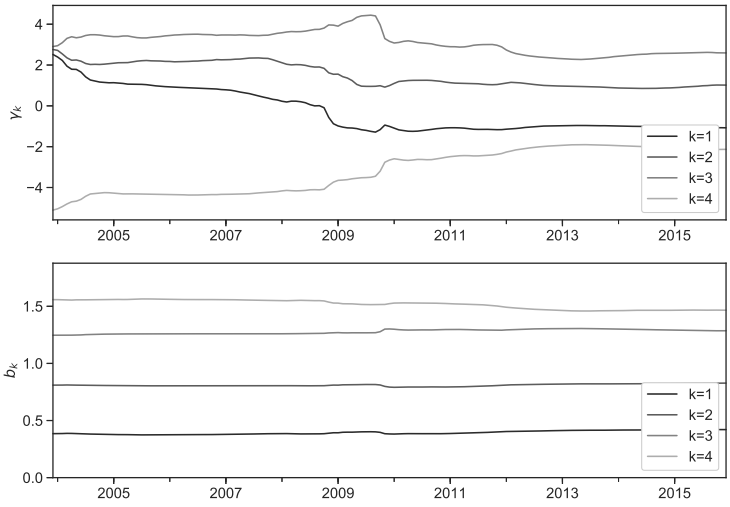

Figure 22: Evolution of parameters in the Free Constant Model (USD)

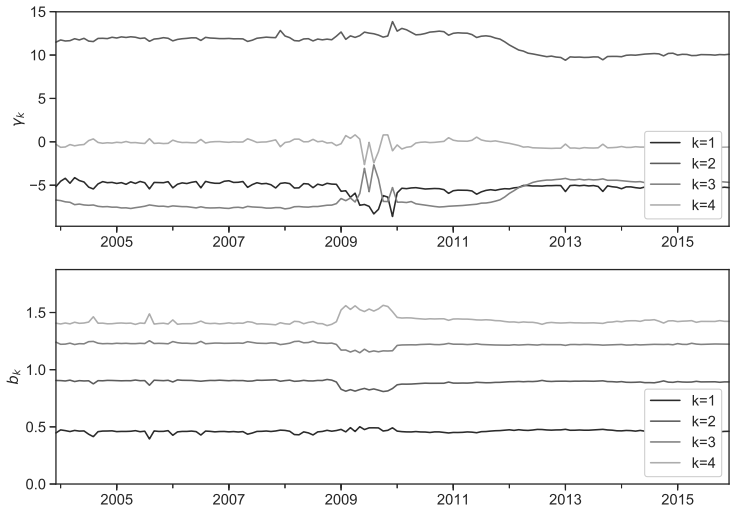

Figure 23: Evolution of parameters in the Free Constant Model (GBP)

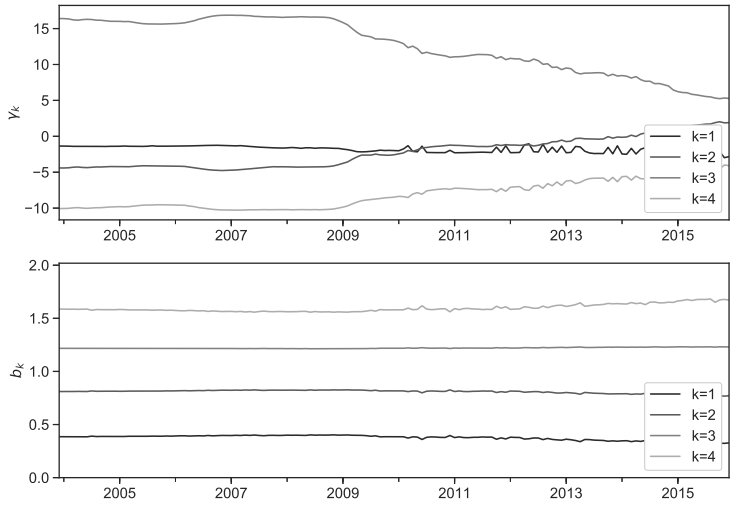

Figure 24: Evolution of parameters in the Free Constant Model (EUR)

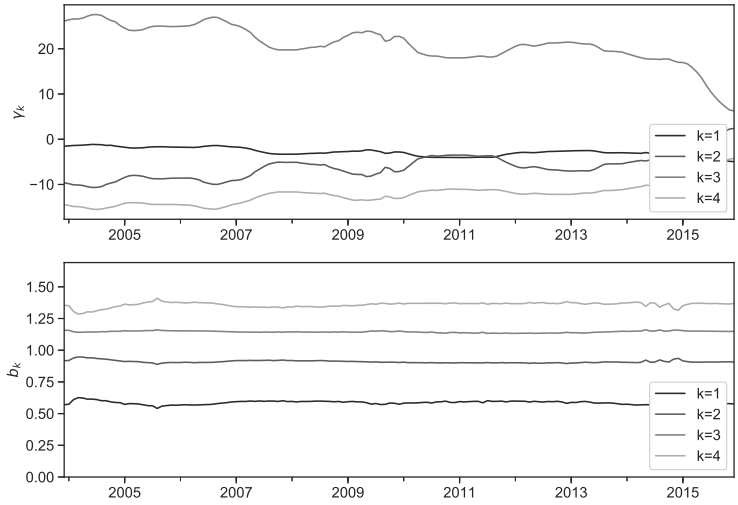

Figure 25: Evolution of parameters in the Free Constant Model (CHF)

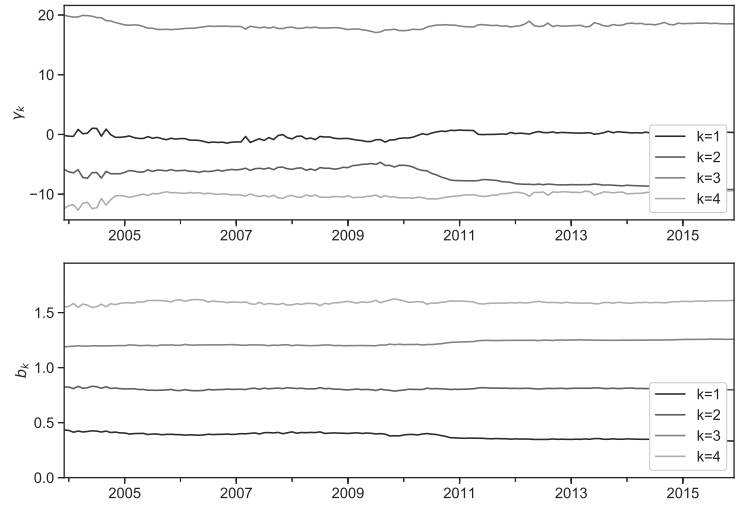

Figure 26: Evolution of parameters in the Free Constant Model (CAD)

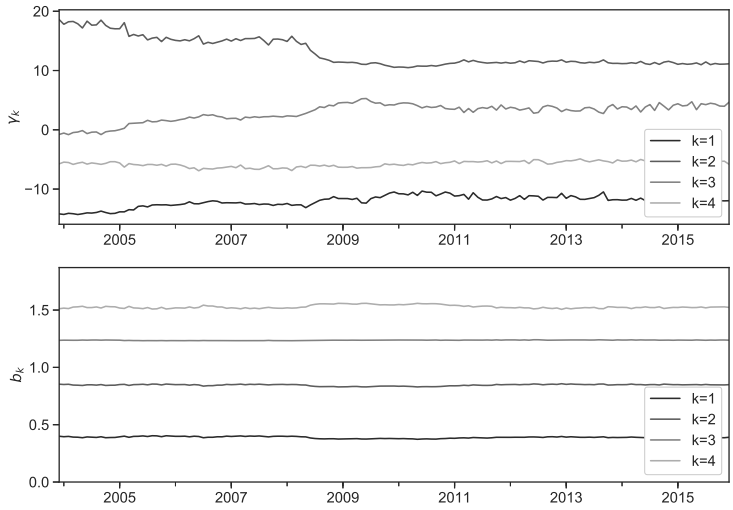

Figure 27: Evolution of parameters in the Free Constant Model (JPY)

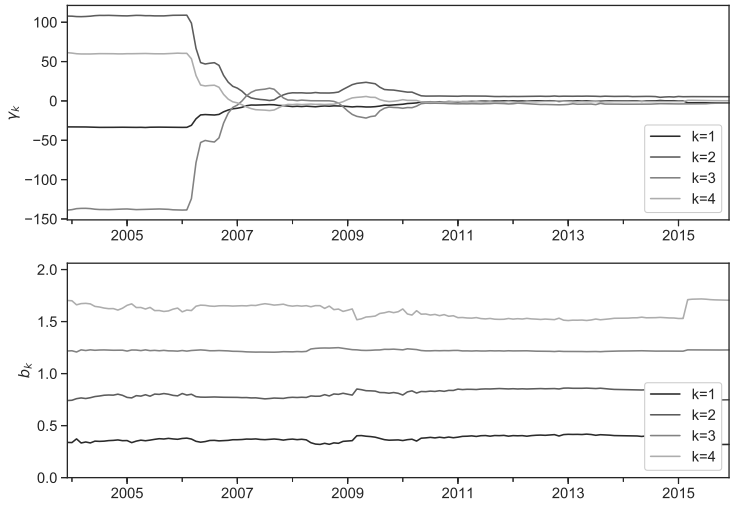

Figure 28: Evolution of parameters in the Free Constant Model (AUD)

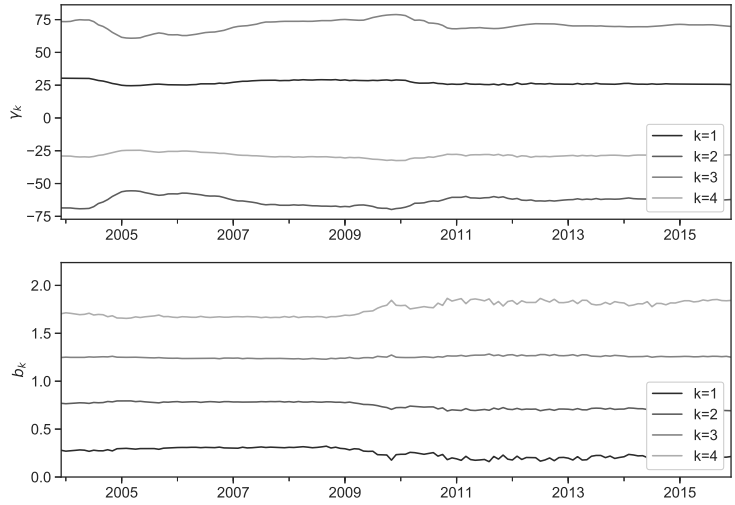

Figure 29: Evolution of parameters in the Free Constant Model (SEK)

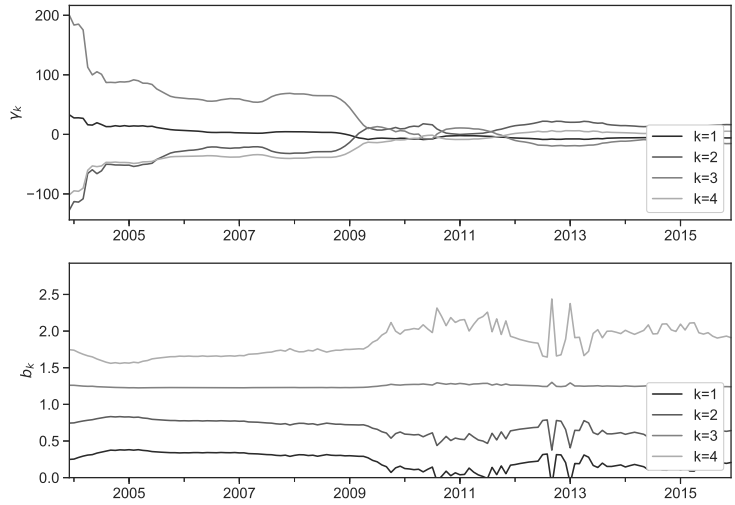

Figure 30: Evolution of parameters in the Free Constant Model (NOK)