Monetary Policy and Bond Prices with Drifting Equilibrium Rates
Online Appendix

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A Additional Results

Table A.1: Testing Parametric Restriction on the Cointegrating Relationship between Yields and Drifting Equilibrium Rates

This table reports OLS estimates for the regression $y_t^{(n)} = \alpha + \beta y_t^{(n),*} + \varepsilon_t$, where $y_t^{(n)}$ is the observed yield at time t of a bond with maturity n-period and $y_t^{(n),*} = \left(\frac{1}{n}\right)\sum_{i=0}^{n-1} E[y_{t+i}^{(1)} \mid I_t]$. Values in parethesis are 95% confidence interval. Costant estimates are not tabulated. Quarterly observations. The sample period is 1980:Q1 to 2019:Q4.

	$y_t^{(8)}$	$y_t^{(12)}$	$y_t^{(20)}$	$y_t^{(28)}$	$y_t^{(40)}$
	1	2	3	4	5
$y_t^{(8),*}$	1.082***				
	(0.950, 1.213)				
$y_t^{(12),*}$		1.059***			
		(0.914, 1.203)			
$y_t^{(20),*}$			1.014***		
			(0.853, 1.174)		
$y_t^{(28),*}$				0.984***	
				(0.810, 1.158)	
$y_t^{(40),*}$					0.960***
					(0.755, 1.165)
Observations	160	160	160	160	160
R^2	0.944	0.930	0.914	0.902	0.888

Table A.2: Predictive Regressions (across different maturities): Slope versus Cyclical Component

This table reports OLS estimates for the regression $rx_{t+4}^{(n)} = \alpha + \beta_1(y_t^{(n)} - y_t^{(4)}) + \beta_2(-(n-4)\ u_t^{(n-4)}) + \epsilon_t$, where $rx_{t+4}^{(n)}$ is the realized one-year holding period excess return of a bond with maturity n-period, $y_t^{(n)} - y_t^{(4)}$ is the slope for a n-period bond, and $(-(n-4)\ u_t^{(n-4)})$ is the deviation of a n-period maturity yield from its drift. Values in parenthesis are conservative standard errors from reverse regressions computed as in Hodrick (1992). Constant estimates are not tabulated. Quarterly observations. The sample period is 1980:Q1 to 2019:Q4.

	$rx_{t+4}^{(8)}$		$rx_{t+4}^{(12)}$		$rx_{t+4}^{(20)}$		$rx_{t+4}^{(28)}$	
	1	2	3	4	5	6	7	8
$y_t^{(8)} - y_t^{(4)}$	1.389*							
	(0.832)							
$-(8-4)\ u_t^{(4)}$	−1.237***	−1.187***						
	(0.301)	(0.271)						
$y_t^{(12)} - y_t^{(4)}$			1.587*					
			(0.865)					
$-(12-4)\ u_t^{(8)}$			−0.886***	−0.857***				
			(0.189)	(0.178)				
$y_t^{(20)} - y_t^{(4)}$					1.474*			
					(0.773)			
$-(20-4)\ u_t^{(16)}$					−0.765***	−0.790***		
					(0.122)	(0.148)		
$y_t^{(28)} - y_t^{(4)}$							1.265	
							(0.914)	
$-(28-4)\ u_t^{(24)}$							−0.704***	−0.745***
							(0.117)	(0.127)
Observations	156	156	156	156	156	156	156	156
Adjusted R^2	0.319	0.259	0.341	0.276	0.361	0.319	0.356	0.334

Table A.3: Predictive Regressions (quarterly holding period returns): Slope versus Cyclical component

This table reports OLS estimates for the regression $rx_{t+1}^{(n)} = \alpha + \beta_1(y_t^{(n)} - y_t^{(1)}) + \beta_2(-(n-1)\ u_t^{(n-1)}) + \epsilon_t$, where $rx_{t+1}^{(n)}$ is the realized one-quarter holding period excess return of a bond with maturity n-period, $y_t^{(n)} - y_t^{(1)}$ is the slope for a n-period bond, and $(-(n-1)\ u_t^{(n-1)})$ is the deviation of a n-period maturity yield from its drift. Values in parenthesis are heteroskedasticity and autocorrelation consistent (HAC) standard errors with automatic bandwidth selection procedure as described in Newey and West (1994). Constant estimates are not tabulated. Quarterly observations. The sample period is 1980:Q1 to 2019:Q4.

	$rx_{t+1}^{(8)}$	$rx_{t+1}^{(12)}$	$rx_{t+1}^{(20)}$	$rx_{t+1}^{(28)}$	$rx_{t+1}^{(40)}$
	1	2	3	4	5
$y_t^{(8)} - y_t^{(1)}$	-0.151^{*}				
	(0.084)				
$-(8-1)\ u_t^{(7)}$	-0.146^{***}				
	(0.036)				
$y_t^{(12)} - y_t^{(1)}$		-0.103			
		(0.154)			
$-(12-1)\ u_t^{(11)}$		-0.183^{***}			
		(0.043)			
$y_t^{(20)} - y_t^{(1)}$			-0.026		
			(0.213)		
$-(20-1)\ u_t^{(19)}$			-0.183^{***}		
			(0.046)		
$y_t^{(28)} - y_t^{(1)}$				0.025	
				(0.251)	
$-(28-1)\ u_t^{(27)}$				-0.172^{***}	
				(0.045)	
$y_t^{(40)} - y_t^{(1)}$					0.021
					(0.310)
$-(40-1)\ u_t^{(39)}$					-0.159^{***}
					(0.045)
Observations	159	159	159	159	159
R^2	0.140	0.130	0.116	0.108	0.094

Table A.4: Out-Of-Sample Tests: Deterministic Trend

This table is similar to Table **??** in the main manuscript and reports R^2_{OOS} for the predictive regression $rx^{(n)}_{t+4} = \alpha + \beta' \tilde{u}_t + \epsilon_t$ where $rx^{(n)}_{t+4}$ is the realized one-year holding period excess return of a bond with maturity n-period and $\tilde{u}_t$ is the single-return forecasting factor implied by a model that employs a time trend to capture drifting equilibrium rates. We use a rolling window for estimating the predictive regressions. The R^2_{OOS} is computed as in Campbell and Thompson (2008); p-values for R^2_{OOS} are computed as in Clark and West (2007). In Panel A the out-of-sample period starts in 1990; in Panel B the out-of-sample period starts in 2000. Quarterly observations.

Panel A: Out-of-sample period: 1990-2019.

	$rx^{(8)}_{t+4}$	$rx^{(12)}_{t+4}$	$rx^{(20)}_{t+4}$	$rx^{(28)}_{t+4}$	$rx^{(40)}_{t+4}$
	1	2	3	4	5
R^2_{OOS}	-4.42	-0.75	-0.46	-7.71	-21.42

Panel B: Out-of-sample period: 2000-2019.

	$rx^{(8)}_{t+4}$	$rx^{(12)}_{t+4}$	$rx^{(20)}_{t+4}$	$rx^{(28)}_{t+4}$	$rx^{(40)}_{t+4}$
	1	2	3	4	5
R^2_{OOS}	-22.55	-13.35	-3.86	-30.11	-65.39

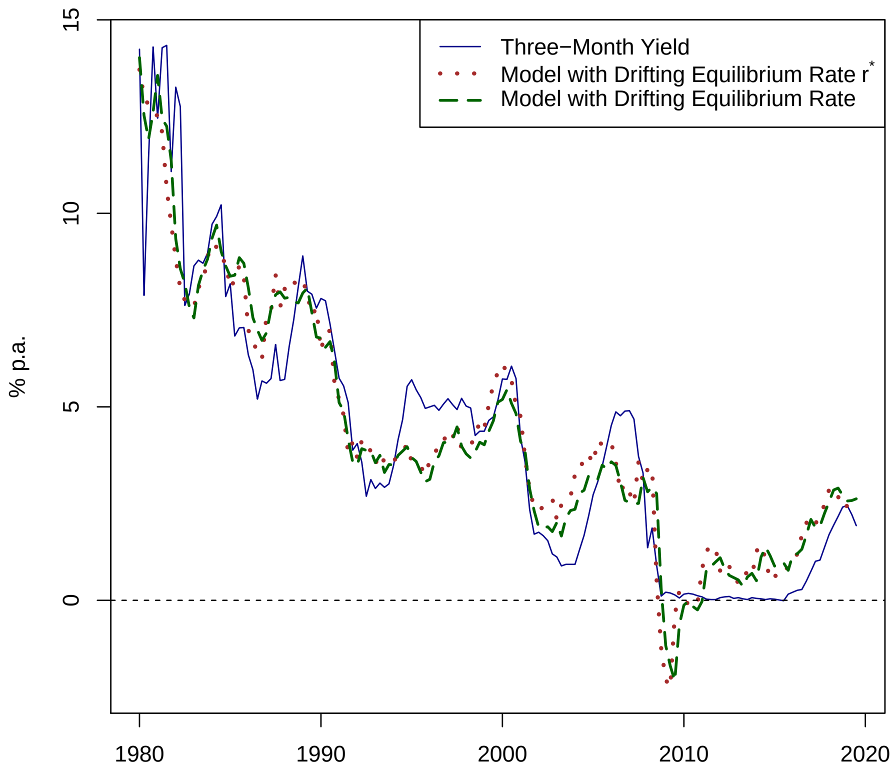


Figure A.1: Actual vs Fitted Short-Term Rate: Equilibrium Real Rate. This figure shows actual three-months yield and fitted values for our baseline (cointegrated) model with drifting equilibrium rates (c.f. equation (2) ; green dashed line), and for a cointegrated rule with r^* (brown dotted line). The estimated cointegrated policy rule with r^* has the following coefficients (HAC standard errors in parenthesis):

$$y_t^{(1)} = \underset{(0.092)}{0.667^{***}} \; r_t^* + \underset{(0.068)}{1.449^{***}} \; \pi_t^* + \underset{(0.173)}{0.822^{***}} \; E_t(\pi_{t+1} - \pi_{t+1}^*) + \underset{(0.083)}{0.318^{***}} \; E_t(x_{t+1}), \;\; R^2 = 94.3\%$$
.

We denote r^* as the equilibrium real rate. We get an estimate for the equilibrium real rate by regressing the real rate $r_t = y_t^{(1)} - E_t(\pi_{t+4})$ on MY and potential output growth. We use as $E_t(\pi_{t+4})$ the expected one-year ahead inflation from the Survey of Professional Forecasters (SPF). The estimates for r^* are:

$$r_t^* = -\underset{(1.397)}{4.040^{***}} \; MY_t + \underset{(0.309)}{1.812^{***}} \; \Delta x_t^{pot}, \; R^2 = 68\% \; .$$

Quarterly observations. The sample period is 1980:Q1 to 2019:Q4.

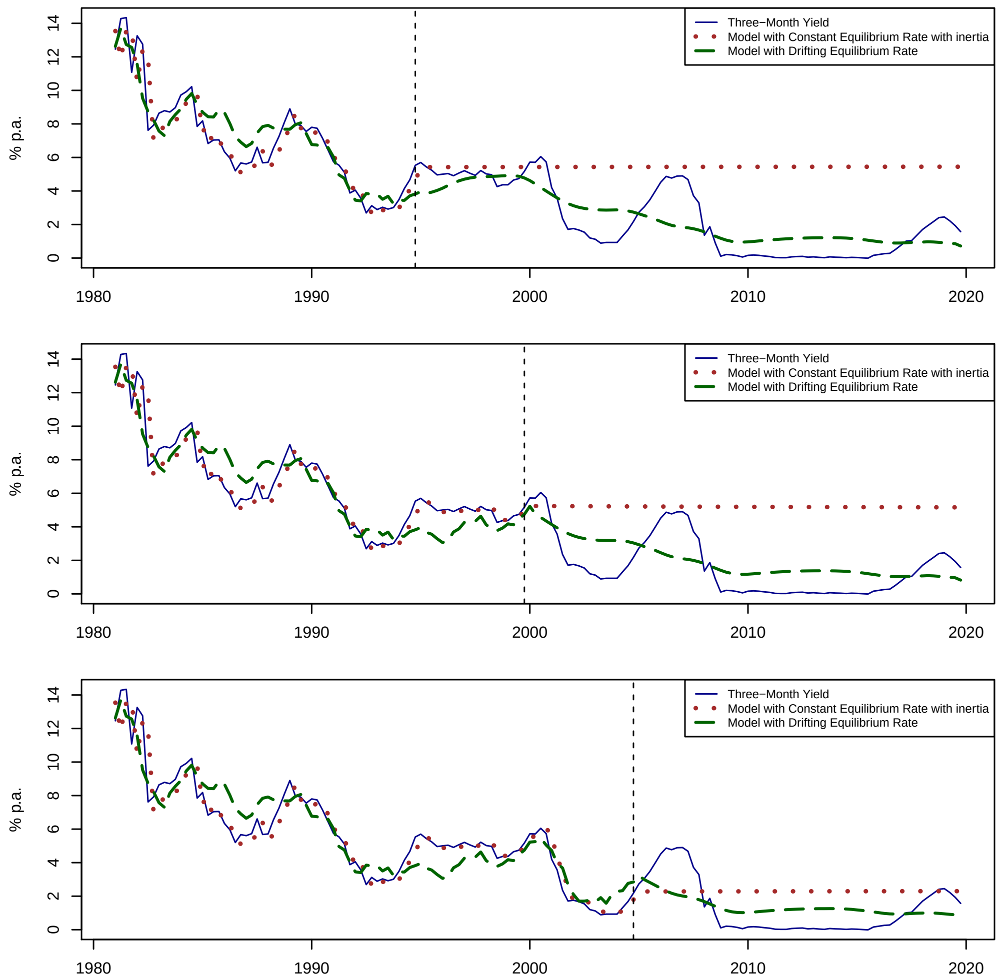


Figure A.2: Long-Term Forecasts of Short-Term Rate: Interest Rate Smoothing (1). This figure shows actual three-months yield and predicted rates implied by equation (2)in case of the policy rule with constant equilibrium rate and interest rate smoothing (brown dotted line) or our baseline (cointegrated) model with drifting equilibrium rates (green dashed line). The estimated empirical Taylor rule with interest rate smoothing (one lag) has the following coefficients (HAC standard errors in parenthesis):

$$y_t^{(1)} = \underset{(0.108)}{0.310}^{***} + \underset{(0.015)}{0.935}^{***}\, y_{t-1}^{(1)} - \underset{(0.140)}{0.034}\, E_t(\pi_{t+1} - \pi_{t+1}^*) + \underset{(0.028)}{0.070}^{**}\, E_t(x_{t+1}),\; R^2 = 92.7\%.$$

Dotted vertical lines represent the end of in-sample estimation period. Quarterly observations. The sample period is 1980:Q1 to 2019:Q4.

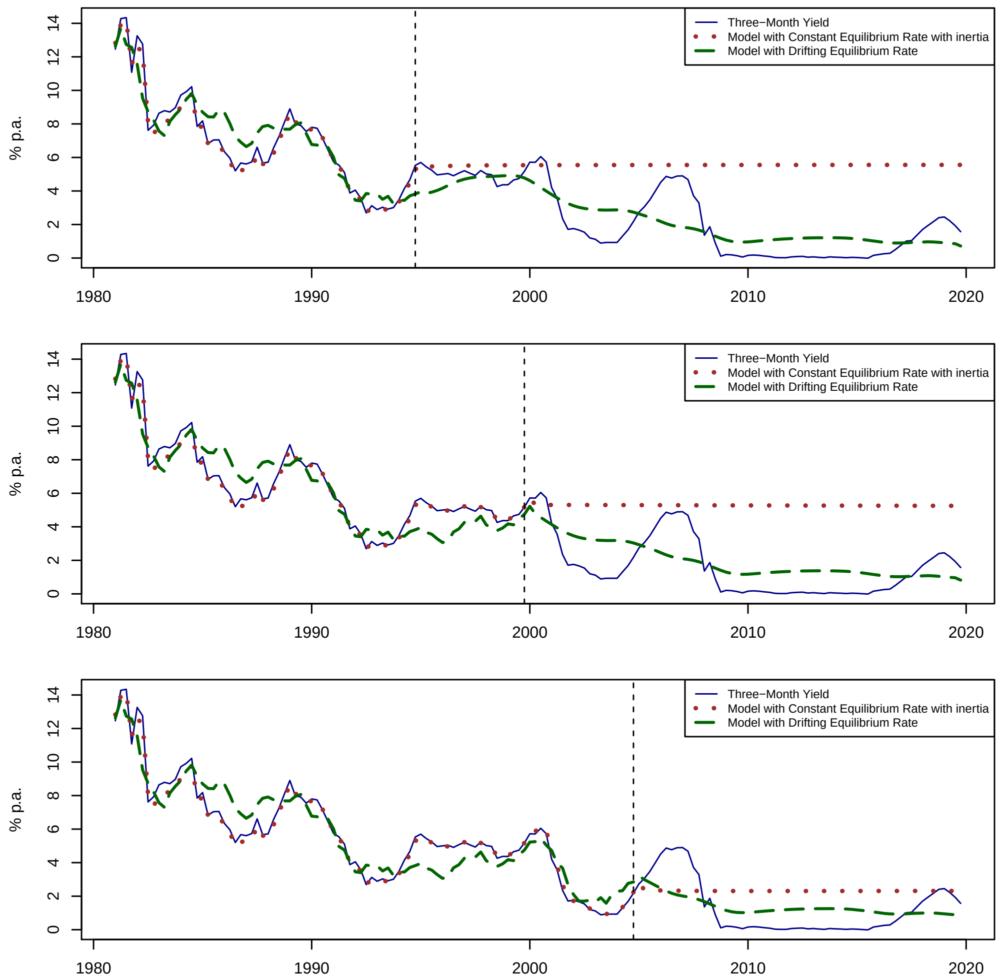
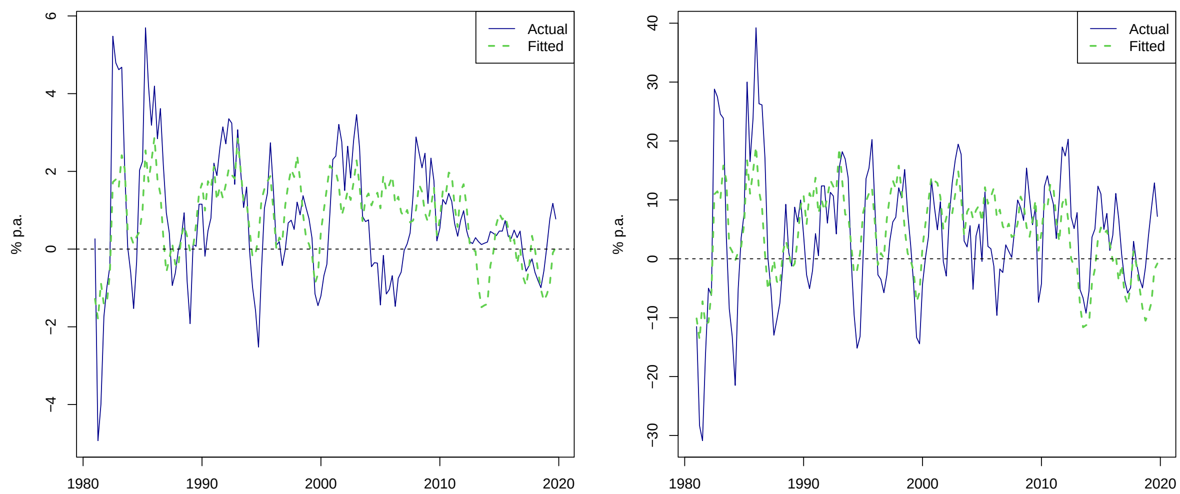


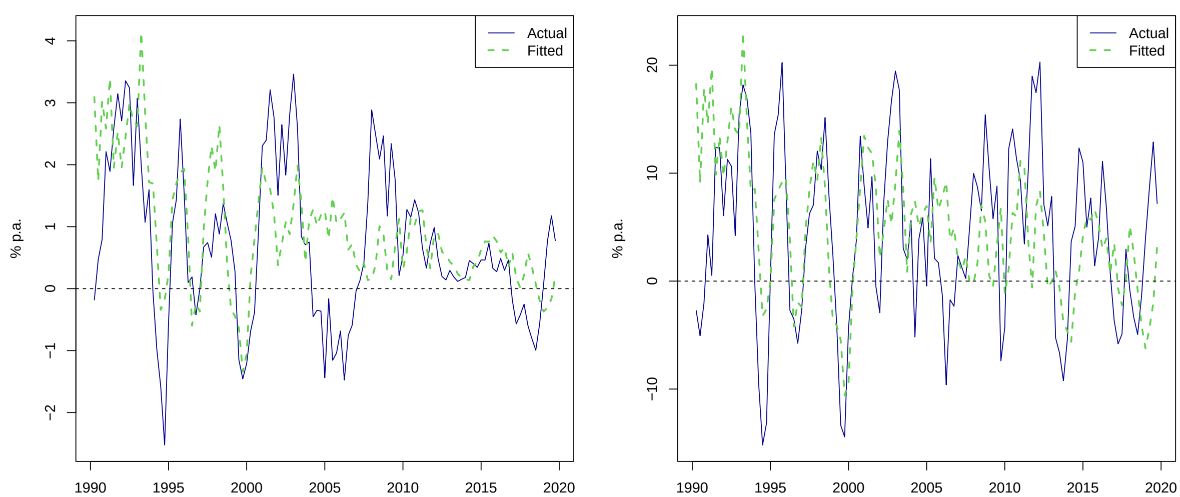
Figure A.3: Long-Term Forecasts of Short-Term Rate: Interest Rate Smoothing (2). This figure shows actual three-months yield and predicted rates implied by equation (2) in case of the policy rule with constant equilibrium rate and interest rate smoothing (brown dotted line) or our baseline (cointegrated) model with drifting equilibrium rates (green dashed line). The estimated empirical Taylor rule with interest rate smoothing (two lags) has the following coefficients (HAC standard errors in parenthesis):

$$y_t^{(1)} = \underset{(0.144)}{0.253^*} + \underset{(0.077)}{0.792^{***}}\, y_{t-1}^{(1)} + \underset{(0.063)}{0.173^{***}}\, y_{t-2}^{(1)} - \underset{(0.082)}{0.185}\, E_t(\pi_{t+1} - \pi_{t+1}^*) + \underset{(0.036)}{0.052^{**}}\, E_t(x_{t+1}),\ R^2 = 94.9\%.$$

Dotted vertical lines represent the end of in-sample estimation period. Quarterly observations. The sample period is 1980:Q1 to 2019:Q4.



(a) In-Sample.



(b) Out-of-Sample.

Figure A.4: Actual vs Predicted Values. These plots shows actual and fitted values for the predictive regression $rx_{t+4}^{(n)} = \alpha + \beta' \tilde{u}_t + \epsilon_t$ where $rx_{t+4}^{(n)}$ is the realized one-year holding period excess return of a bond with maturity n-period and $\tilde{u}_t$ is the single-return forecasting factor implied by our model with drifting equilibrium rates. Panel (a) shows results for the predictive regression in-sample, while Panel (b) shows out-of-sample results. The left–panels show results for $n = 8$ (two-year maturity bond); the right-panels show results for $n = 40$ (ten-year maturity bond). In Panel (b), we use a rolling window for estimating the predictive regressions; the out-of-sample period starts in 1990. $\tilde{u}_t$ is the fitted value from regressing the average one-year holding-period excess returns on a n-periods Treasury bond for $n = 4, 8, \dots, 40$ on our cyclical components $u_t^{(n)}$ $n = 1, \dots, 40$. Quarterly observations. The sample period is 1980:Q1 to 2019:Q4.

B International Evidence

Table B.1: Predictive Regressions (across different maturities): Slope versus Cyclical Component

This table reports OLS estimates for the regression $rx_{t+4}^{(n)} = \alpha + \beta_1(y_t^{(n)} - y_t^{(4)}) + \beta_2(-(n-4)\ u_t^{(n-4)}) + \epsilon_t$, where $rx_{t+4}^{(n)}$ is the realized one-year holding period excess return of a bond with maturity n-period, $y_t^{(n)} - y_t^{(4)}$ is the slope for a n-period bond, and $(-(n-4)\ u_t^{(n-4)})$ is the deviation of a n-period maturity yield from its drift. Values in parenthesis are conservative standard errors from reverse regressions computed as in Hodrick (1992). Constant estimates are not tabulated. Quarterly observations. For UK, zero-coupon bonds data are from the Bank of England (https://www.bankofengland.co.uk/statistics/yield-curves); the sample period is 1980:Q1 to 2019:Q4. For Canada, zero-coupon bonds data are from the Bank of Canada (https://www.bankofcanada.ca/rates/interest-rates/bond-yield-curves/); the sample period is 1986:Q1 to 2019:Q4.

Panel A: UK.

	$rx_{t+4}^{(12)}$		$rx_{t+4}^{(20)}$		$rx_{t+4}^{(40)}$	
	1	2	3	4	5	6
$y_t^{(12)} - y_t^{(4)}$	1.152					
	(0.737)					
$-(12-4)\ u_t^{(8)}$	-0.350^{**}	-0.371^{**}				
	(0.140)	(0.144)				
$y_t^{(20)} - y_t^{(4)}$			1.537^{**}			
			(0.749)			
$-(20-4)\ u_t^{(16)}$			-0.336^{***}	-0.344^{***}		
			(0.106)	(0.109)		
$y_t^{(40)} - y_t^{(4)}$					1.970^{*}	
					(1.103)	
$-(40-4)\ u_t^{(36)}$					-0.289^{***}	-0.291^{***}
					(0.091)	(0.095)
Observations	156	156	156	156	156	156
Adjusted R^2	0.126	0.071	0.149	0.081	0.159	0.089

Panel B: Canada.

	$rx_{t+4}^{(12)}$		$rx_{t+4}^{(20)}$		$rx_{t+4}^{(40)}$	
	1	2	3	4	5	6
$y_t^{(12)} - y_t^{(4)}$	1.062					
	(0.792)					
$-(12-4)\ u_t^{(8)}$	-0.478^{***}	-0.511^{***}				
	(0.146)	(0.141)				
$y_t^{(20)} - y_t^{(4)}$			1.362^{*}			
			(0.781)			
$-(20-4)\ u_t^{(16)}$			-0.422^{***}	-0.456^{***}		
			(0.107)	(0.102)		
$y_t^{(40)} - y_t^{(4)}$					1.883^{*}	
					(1.136)	
$-(40-4)\ u_t^{(36)}$					-0.330^{***}	-0.393^{***}
					(0.116)	(0.104)
Observations	132	132	132	132	132	132
Adjusted R^2	0.214	0.159	0.256	0.194	0.262	0.203