

Demographics and The Behavior of Interest Rates

Online Appendix

Table A.1. Middle-aged to Old (MO)
Affine Model Out-of-Sample Forecasts

Panel A. Random walk Benchmark										
h	4		8		12		16		20	
	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)
$\hat{y}_{t+h t}^{(1/4)}$	1.249 (0.020)	1.642 (0.050)	1.047 (0.001)	4.764 (0.000)	0.970 (0.000)	7.594 (0.000)	0.989 (0.000)	6.885 (0.000)	1.105 (0.000)	2.870 (0.002)
$\hat{y}_{t+h t}^{(1)}$	1.180 (0.001)	1.321 (0.093)	1.020 (0.004)	4.447 (0.000)	0.958 (0.001)	6.790 (0.000)	0.976 (0.001)	5.680 (0.000)	1.085 (0.001)	2.180 (0.015)
$\hat{y}_{t+h t}^{(2)}$	1.187 (0.011)	0.915 (0.180)	1.053 (0.000)	3.714 (0.000)	1.005 (0.005)	5.361 (0.000)	1.029 (0.018)	3.892 (0.000)	1.129 (0.076)	0.399 (0.345)
$\hat{y}_{t+h t}^{(3)}$	1.196 (0.001)	0.714 (0.238)	1.086 (0.019)	3.144 (0.001)	1.053 (0.000)	4.188 (0.000)	1.076 (0.144)	2.463 (0.007)	1.164 (0.194)	-1.337 (0.910)
$\hat{y}_{t+h t}^{(4)}$	1.202 (0.000)	0.585 (0.279)	1.115 (0.000)	2.681 (0.004)	1.092 (0.001)	3.221 (0.001)	1.112 (0.000)	1.319 (0.094)	1.189 (0.030)	-2.848 (0.998)
$\hat{y}_{t+h t}^{(5)}$	1.204 (0.000)	0.486 (0.313)	1.137 (0.000)	2.292 (0.011)	1.123 (0.000)	2.414 (0.008)	1.138 (0.000)	0.410 (0.341)	1.204 (0.000)	-4.031 (1.000)

Panel B. Macro ATSM Benchmark										
h	4		8		12		16		20	
	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)
$\hat{y}_{t+h t}^{(1/4)}$	1.082 (0.000)	1.805 (0.036)	0.995 (0.001)	4.403 (0.000)	0.928 (0.005)	1.791 (0.037)	0.888 (0.017)	1.627 (0.052)	0.897 (0.037)	3.117 (0.001)
$\hat{y}_{t+h t}^{(1)}$	1.033 (0.006)	2.832 (0.002)	0.950 (0.044)	4.816 (0.000)	0.887 (0.053)	2.599 (0.005)	0.865 (0.060)	2.376 (0.009)	0.882 (0.016)	3.735 (0.000)
$\hat{y}_{t+h t}^{(2)}$	1.014 (0.001)	3.289 (0.001)	0.925 (0.007)	4.765 (0.000)	0.865 (0.014)	3.123 (0.001)	0.853 (0.015)	2.906 (0.002)	0.873 (0.017)	3.979 (0.000)
$\hat{y}_{t+h t}^{(3)}$	1.007 (0.001)	3.456 (0.000)	0.912 (0.014)	4.688 (0.000)	0.851 (0.026)	3.461 (0.000)	0.845 (0.033)	3.207 (0.001)	0.868 (0.040)	4.042 (0.000)
$\hat{y}_{t+h t}^{(4)}$	1.005 (0.002)	3.536 (0.000)	0.903 (0.016)	4.657 (0.000)	0.841 (0.028)	3.728 (0.000)	0.840 (0.033)	3.425 (0.000)	0.865 (0.041)	4.060 (0.000)
$\hat{y}_{t+h t}^{(5)}$	1.007 (0.000)	3.570 (0.000)	0.897 (0.001)	4.653 (0.000)	0.835 (0.003)	3.944 (0.000)	0.835 (0.003)	3.589 (0.000)	0.862 (0.003)	4.055 (0.000)

Notes. This table reports international evidence. Pooled regression coefficients account for country fixed effects. This table provides yield forecast comparison of Demographic ATSM using middle-aged to old (MO) against the RandomWalk model (Panel A) and Macro ATSM (Panel B) benchmarks. MO is constructed as ratio of the middle-aged cohort, age 40–49, to the old-age cohort, age 60–69. We use the in-sample estimators, from 1961Q3 to 1981Q2, to generate out-of-sample forecasts until 2013Q4. h indicates 4, 8, 12, 16, 20 quarter out-of-sample forecasts. We measure forecasting performance as the ratio of the root mean squared forecast error (RMSFE) of our model against the benchmarks. We report in parentheses the p-values of the forecasting test due to Giacomini and White (2006) in the columns with FRMSE. A p-value below 0.01 (0.05, 0.10) indicates a significant difference in forecasting performance at the 1% (5%, 10%) level. We also measure forecasting performance using Clark and West (2006, 2007) test. We report the test statistics in the columns CW for each horizon together with p-values in parentheses below. Quarterly sample 1981Q3-2013Q4.

Table A.2. MA inflation (Cieslak-Povala)
Affine Model Out-of-Sample Forecasts

Panel A. Random walk Benchmark										
h	4		8		12		16		20	
	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)
$\hat{y}_{t+h t}^{(1/4)}$	1.477 (0.026)	0.268 (0.394)	1.222 (0.002)	2.892 (0.002)	1.146 (0.000)	4.266 (0.000)	1.171 (0.000)	3.448 (0.000)	1.280 (0.002)	0.772 (0.220)
$\hat{y}_{t+h t}^{(1)}$	1.462 (0.016)	0.109 (0.457)	1.231 (0.001)	2.447 (0.007)	1.164 (0.000)	3.540 (0.000)	1.168 (0.007)	2.626 (0.004)	1.257 (0.207)	0.185 (0.427)
$\hat{y}_{t+h t}^{(2)}$	1.513 (0.000)	-0.195 (0.577)	1.309 (0.038)	1.598 (0.055)	1.248 (0.000)	2.215 (0.013)	1.239 (0.052)	1.114 (0.133)	1.309 (0.059)	-1.460 (0.928)
$\hat{y}_{t+h t}^{(3)}$	1.559 (0.000)	-0.411 (0.660)	1.387 (0.000)	0.823 (0.205)	1.330 (0.001)	0.981 (0.163)	1.305 (0.256)	-0.252 (0.599)	1.354 (0.009)	-3.108 (0.999)
$\hat{y}_{t+h t}^{(4)}$	1.592 (0.000)	-0.578 (0.718)	1.453 (0.000)	0.124 (0.451)	1.400 (0.000)	-0.139 (0.555)	1.360 (0.362)	-1.464 (0.928)	1.387 (0.000)	-4.629 (1.000)
$\hat{y}_{t+h t}^{(5)}$	1.611 (0.000)	-0.705 (0.760)	1.504 (0.000)	-0.498 (0.691)	1.456 (0.000)	-1.146 (0.874)	1.402 (0.115)	-2.528 (0.994)	1.411 (0.000)	-5.937 (1.000)

Panel B. Macro ATSM Benchmark										
h	4		8		12		16		20	
	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)
$\hat{y}_{t+h t}^{(1/4)}$	1.279 (0.000)	-2.661 (0.996)	1.161 (0.000)	-2.660 (0.996)	1.096 (0.002)	-2.482 (0.994)	1.050 (0.010)	-2.832 (0.998)	1.039 (0.029)	-3.559 (1.000)
$\hat{y}_{t+h t}^{(1)}$	1.280 (0.004)	-2.660 (0.996)	1.146 (0.034)	-2.383 (0.991)	1.079 (0.070)	-2.077 (0.981)	1.035 (0.099)	-2.527 (0.994)	1.022 (0.140)	-3.475 (1.000)
$\hat{y}_{t+h t}^{(2)}$	1.292 (0.020)	-3.001 (0.999)	1.151 (0.014)	-2.396 (0.992)	1.073 (0.028)	-1.946 (0.974)	1.027 (0.031)	-2.334 (0.990)	1.012 (0.203)	-3.447 (1.000)
$\hat{y}_{t+h t}^{(3)}$	1.312 (0.000)	-3.486 (1.000)	1.164 (0.002)	-2.624 (0.996)	1.075 (0.005)	-2.005 (0.978)	1.026 (0.006)	-2.280 (0.989)	1.010 (0.006)	-3.453 (1.000)
$\hat{y}_{t+h t}^{(4)}$	1.331 (0.000)	-3.898 (1.000)	1.177 (0.000)	-2.853 (0.998)	1.078 (0.002)	-2.085 (0.982)	1.027 (0.003)	-2.233 (0.987)	1.009 (0.004)	-3.421 (1.000)
$\hat{y}_{t+h t}^{(5)}$	1.347 (0.000)	-4.182 (1.000)	1.187 (0.000)	-3.042 (0.999)	1.082 (0.002)	-2.164 (0.985)	1.029 (0.004)	-2.206 (0.986)	1.010 (0.005)	-3.396 (1.000)

Notes. This table reports international evidence. Pooled regression coefficients account for country fixed effects. This table provides yield forecast comparison of Demographic ATSM using Cieslak-Povala (CP) trend against the RandomWalk model (Panel A) and Macro ATSM (Panel B) benchmarks. We use the in-sample estimators, from 1961Q3 to 1981Q2, to generate out-of-sample forecasts until 2013Q4. h indicates 4, 8, 12, 16, 20 quarter out-of-sample forecasts. We measure forecasting performance as the ratio of the root mean squared forecast error (RMSFE) of our model against the benchmarks. We report in parentheses the p-values of the forecasting test due to Giacomini and White (2006) in the columns with FRMSE. A p-value below 0.01 (0.05, 0.10) indicates a significant difference in forecasting performance at the 1% (5%, 10%) level. We also measure forecasting performance using Clark and West (2006, 2007) test. We report the test statistics in the columns CW for each horizon together with p-values in parentheses below. Quarterly sample 1981Q3-2013Q4.

Table A.3. Alternative Permanent Components
Out-of-Sample Forecasts Comparison

Panel A. AFNS vs. Demographic ATSM (constant risk premium)					
h	4	8	12	16	20
	RMSFE (GW)	RMSFE (GW)	RMSFE (GW)	RMSFE (GW)	RMSFE (GW)
$\hat{y}_{t+h t}^{(1/4)}$	1.072 (0.000)	0.925 (0.000)	0.854 (0.000)	0.889 (0.001)	0.964 (0.002)
$\hat{y}_{t+h t}^{(1)}$	1.055 (0.014)	0.931 (0.003)	0.869 (0.004)	0.903 (0.004)	0.973 (0.000)
$\hat{y}_{t+h t}^{(2)}$	1.040 (0.129)	0.922 (0.161)	0.877 (0.156)	0.907 (0.145)	0.968 (0.144)
$\hat{y}_{t+h t}^{(3)}$	1.035 (0.014)	0.920 (0.011)	0.884 (0.013)	0.911 (0.016)	0.963 (0.014)
$\hat{y}_{t+h t}^{(4)}$	1.030 (0.024)	0.920 (0.016)	0.891 (0.021)	0.912 (0.031)	0.956 (0.050)
$\hat{y}_{t+h t}^{(5)}$	1.0211 (0.019)	0.919 (0.024)	0.896 (0.031)	0.911 (0.039)	0.946 (0.056)
Panel B. AFNS vs. Demographic ATSM (time-varying risk premium)					
h	4	8	12	16	20
	RMSFE (GW)	RMSFE (GW)	RMSFE (GW)	RMSFE (GW)	RMSFE (GW)
$\hat{y}_{t+h t}^{(1/4)}$	1.047 (0.000)	0.852 (0.000)	0.717 (0.000)	0.713 (0.001)	0.746 (0.004)
$\hat{y}_{t+h t}^{(1)}$	1.017 (0.004)	0.848 (0.006)	0.727 (0.025)	0.721 (0.040)	0.752 (0.007)
$\hat{y}_{t+h t}^{(2)}$	1.000 (0.076)	0.834 (0.153)	0.730 (0.210)	0.720 (0.261)	0.746 (0.256)
$\hat{y}_{t+h t}^{(3)}$	0.993 (0.053)	0.828 (0.142)	0.734 (0.222)	0.721 (0.289)	0.742 (0.301)
$\hat{y}_{t+h t}^{(4)}$	0.986 (0.121)	0.822 (0.227)	0.736 (0.304)	0.720 (0.359)	0.736 (0.400)
$\hat{y}_{t+h t}^{(5)}$	0.975 (0.172)	0.815 (0.237)	0.736 (0.277)	0.718 (0.298)	0.729 (0.319)

Note. This table provides yield forecast comparison of Demographic ATSM and the arbitrage-free Nelson-Siegel term structure model (independent factor case) benchmark. In Panel A, the Demographic ATSM model assumes a constant risk premium, while Panel B shows the results of Demographic ATSM with time-varying risk premium. We use the in-sample estimators, from 1961Q3 to 1981Q2, to generate out-of-sample forecasts until 2013Q4. h indicates 4, 8, 12, 16, 20 quarter out-of-sample forecasts. We measure forecasting performance as the ratio of the root mean squared forecast error (RMSFE) of our model against the benchmark. We report in parentheses the p-values of the forecasting test due to Giacomini and White (2006) in the columns with RMSFE. A p-value below 0.01 (0.05, 0.10) indicates a significant difference in forecasting performance at the 1% (5%, 10%) level. Quarterly sample 1981Q3-2013Q4.

Table A.4. MY adjusted for foreign treasury holdings
Affine Model Out-of-Sample Forecasts

Panel A. Random walk Benchmark										
h	4		8		12		16		20	
	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)
$\hat{y}_{t+h t}^{(1/4)}$	1.223 (0.001)	1, 221 (0.2111)	0.992 (0.003)	3.859 (0.000)	0.920 (0.000)	6.089 (0.000)	0.940 (0.000)	7.106 (0.000)	1.022 (0.000)	6.939 (0.000)
$\hat{y}_{t+h t}^{(1)}$	1.122 (0.001)	0.823 (0.205)	0.957 (0.006)	3.799 (0.000)	0.906 (0.001)	5.956 (0.000)	0.928 (0.000)	6.606 (0.000)	1.005 (0.001)	6.331 (0.000)
$\hat{y}_{t+h t}^{(2)}$	1.094 (0.047)	0.569 (0.285)	0.973 (0.005)	3.319 (0.001)	0.952 (0.001)	5.042 (0.000)	0.991 (0.061)	5.351 (0.000)	1.071 (0.193)	5.140 (0.000)
$\hat{y}_{t+h t}^{(3)}$	1.078 (0.003)	0.533 (0.297)	0.995 (0.325)	2.861 (0.002)	1.004 (0.002)	4.031 (0.000)	1.056 (0.059)	4.154 (0.000)	1.137 (0.276)	4.070 (0.000)
$\hat{y}_{t+h t}^{(4)}$	1.066 (0.000)	0.573 (0.283)	1.015 (0.070)	2.445 (0.007)	1.054 (0.270)	3.045 (0.001)	1.116 (0.043)	3.084 (0.001)	1.197 (0.095)	3.162 (0.001)
$\hat{y}_{t+h t}^{(5)}$	1.057 (0.000)	0.653 (0.257)	1.033 (0.001)	2.090 (0.018)	1.098 (0.040)	2.180 (0.015)	1.169 (0.081)	2.211 (0.014)	1.251 (0.071)	2.449 (0.007)
Panel B. Macro ATSM Benchmark										
h	4		8		12		16		20	
	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)
$\hat{y}_{t+h t}^{(1/4)}$	1.059 (0.000)	2.464 (0.007)	0.942 (0.001)	7.862 (0.000)	0.880 (0.005)	8.696 (0.000)	0.843 (0.014)	7.324 (0.000)	0.830 (0.022)	4.940 (0.000)
$\hat{y}_{t+h t}^{(1)}$	0.982 (0.001)	3.643 (0.000)	0.891 (0.002)	8.814 (0.000)	0.839 (0.002)	9.418 (0.000)	0.823 (0.004)	7.820 (0.000)	0.817 (0.001)	5.269 (0.000)
$\hat{y}_{t+h t}^{(2)}$	0.934 (0.000)	4.400 (0.000)	0.856 (0.001)	9.414 (0.000)	0.819 (0.001)	9.527 (0.000)	0.821 (0.000)	7.795 (0.000)	0.828 (0.000)	5.529 (0.000)
$\hat{y}_{t+h t}^{(3)}$	0.907 (0.000)	4.863 (0.000)	0.835 (0.000)	9.635 (0.000)	0.812 (0.000)	9.377 (0.000)	0.830 (0.000)	7.621 (0.000)	0.848 (0.000)	5.636 (0.000)
$\hat{y}_{t+h t}^{(4)}$	0.892 (0.000)	5.166 (0.000)	0.822 (0.000)	9.640 (0.000)	0.812 (0.000)	9.121 (0.000)	0.843 (0.000)	7.431 (0.000)	0.871 (0.000)	5.673 (0.000)
$\hat{y}_{t+h t}^{(5)}$	0.884 (0.000)	5.353 (0.000)	0.815 (0.000)	9.493 (0.000)	0.816 (0.000)	8.812 (0.000)	0.858 (0.000)	7.239 (0.000)	0.896 (0.000)	5.671 (0.000)

Notes. This table reports international evidence. Pooled regression coefficients account for country fixed effects. This table provides yield forecast comparison of Demographic ATSM using MY adjusted for foreign holdings against the Random Walk model (Panel A) and Macro ATSM (Panel B) benchmarks. We use the in-sample estimators, from 1961Q3 to 1981Q2, to generate out-of-sample forecasts until 2013Q4. h indicates 4, 8, 12, 16, 20 quarter out-of-sample forecasts. We measure forecasting performance as the ratio of the root mean squared forecast error (RMSFE) of our model against the benchmarks. We report in parentheses the p-values of the forecasting test due to Giacomini and White (2006) in the columns with FRMSE. A p-value below 0.01 (0.05, 0.10) indicates a significant difference in forecasting performance at the 1% (5%, 10%) level. We also measure forecasting performance using Clark and West (2006, 2007) test. We report the test statistics in the columns CW for each horizon together with p-values in parentheses below. Quarterly sample 1981Q3-2013Q4.

Table A.5. Global MY
Affine Model Out-of-Sample Forecasts

Panel A. Random walk Benchmark										
h	4		8		12		16		20	
	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)
$\hat{y}_{t+h t}^{(1/4)}$	1.247 (0.020)	1.145 (0.126)	1.035 (0.000)	4.400 (0.000)	0.930 (0.000)	7.159 (0.000)	0.939 (0.000)	7.054 (0.000)	1.036 (0.000)	4.137 (0.000)
$\hat{y}_{t+h t}^{(1)}$	1.76 (0.008)	0.754 (0.226)	1.003 (0.006)	4.301 (0.000)	0.914 (0.002)	6.805 (0.000)	0.918 (0.000)	6.443 (0.000)	1.001 (0.002)	3.919 (0.000)
$\hat{y}_{t+h t}^{(2)}$	1.170 (0.027)	0.421 (0.337)	1.025 (0.001)	3.667 (0.000)	0.952 (0.012)	5.705 (0.000)	0.956 (0.014)	5.194 (0.000)	1.025 (0.042)	3.009 (0.001)
$\hat{y}_{t+h t}^{(3)}$	1.169 (0.004)	0.292 (0.385)	1.050 (0.221)	3.132 (0.001)	0.992 (0.000)	4.732 (0.000)	0.993 (0.079)	4.162 (0.000)	1.046 (0.134)	2.224 (0.013)
$\hat{y}_{t+h t}^{(4)}$	1.167 (0.000)	0.252 (0.401)	1.073 (0.003)	2.710 (0.003)	1.027 (0.225)	3.920 (0.000)	1.022 (0.000)	3.341 (0.000)	1.060 (0.148)	1.624 (0.052)
$\hat{y}_{t+h t}^{(5)}$	1.163 (0.000)	0.260 (0.397)	1.091 (0.000)	2.391 (0.008)	1.055 (0.039)	3.275 (0.001)	1.044 (0.162)	2.693 (0.004)	1.068 (0.000)	1.192 (0.117)

Panel B. Macro ATSM Benchmark										
h	4		8		12		16		20	
	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)	RMSFE (GW)	CW (p-val)
$\hat{y}_{t+h t}^{(1/4)}$	1.080 (0.000)	1.749 (0.040)	0.983 (0.001)	4.562 (0.000)	0.889 (0.003)	3.752 (0.000)	0.843 (0.004)	3.117 (0.001)	0.841 (0.003)	3.720 (0.000)
$\hat{y}_{t+h t}^{(1)}$	1.030 (0.003)	2.584 (0.005)	0.934 (0.014)	5.188 (0.000)	0.846 (0.014)	4.361 (0.000)	0.814 (0.013)	3.926 (0.000)	0.814 (0.003)	4.286 (0.000)
$\hat{y}_{t+h t}^{(2)}$	0.999 (0.001)	3.092 (0.001)	0.901 (0.008)	5.642 (0.000)	0.818 (0.011)	4.881 (0.000)	0.793 (0.012)	4.554 (0.000)	0.793 (0.014)	4.650 (0.000)
$\hat{y}_{t+h t}^{(3)}$	0.984 (0.000)	3.437 (0.000)	0.882 (0.005)	5.963 (0.000)	0.802 (0.012)	5.244 (0.000)	0.780 (0.018)	4.905 (0.000)	0.780 (0.026)	4.806 (0.000)
$\hat{y}_{t+h t}^{(4)}$	0.975 (0.000)	3.739 (0.000)	0.870 (0.003)	6.229 (0.000)	0.791 (0.010)	5.524 (0.000)	0.772 (0.017)	5.125 (0.000)	0.771 (0.023)	4.873 (0.000)
$\hat{y}_{t+h t}^{(5)}$	0.972 (0.000)	4.003 (0.000)	0.862 (0.001)	6.439 (0.000)	0.784 (0.003)	5.740 (0.000)	0.766 (0.005)	5.266 (0.000)	0.765 (0.006)	4.892 (0.000)

Notes. This table reports international evidence. Pooled regression coefficients account for country fixed effects. This table provides yield forecast comparison of Demographic ATSM using global MY (an equally-weighted average of foreign MY variables) against the Random Walk model (Panel A) and Macro ATSM (Panel B) benchmarks. We use the in-sample estimators, from 1961Q3 to 1981Q2, to generate out-of-sample forecasts until 2013Q4. h indicates 4, 8, 12, 16, 20 quarter out-of-sample forecasts. We measure forecasting performance as the ratio of the root mean squared forecast error (RMSFE) of our model against the benchmarks. We report in parentheses the p-values of the forecasting test due to Giacomini and White (2006) in the columns with FRMSE. A p-value below 0.01 (0.05, 0.10) indicates a significant difference in forecasting performance at the 1% (5%, 10%) level. We also measure forecasting performance using Clark and West (2006, 2007) test. We report the test statistics in the columns CW for each horizon together with p-values in parentheses below. Quarterly sample 1981Q3-2013Q4.