# "Anticipating Long-Term Stock Market Volatility" Supplementary Appendix*

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This online Supplementary Appendix presents full estimation results for the one- and two-sided GARCH-MIDAS-X specifications in Sections 4.1 and 4.2 (Tables A.1 and A.2), a comparison of the weighting schemes and the long-term volatility components for the GARCH-MIDAS-RV, the GARCH-MIDAS-X, and the combined GARCH-MIDAS-RV-X models from Section 4.1.2 (Figures B.1 and B.2), the forecast evaluation of the GARCH-MIDAS-RV-X models in Section 4.3 (Table A.3), as well as all results from Section 4.4 (Tables A.4 - A.11 and Figure B.3).

*All sections, equations, and tables referred to are those of this paper.

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# A Tables

Table A.1: One-sided GARCH-MIDAS-X specifications

| Variable | $\mu$ | $\alpha$ | $\beta$ | $\gamma$ | $m$ | $\theta$ | $\omega_1$ | $\omega_2$ | LLF | BIC | VR(X) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Δ real GDP** | $0.0267^{***}$ (0.0086) | $0.0182^{***}$ (0.0050) | $0.9188^{***}$ (0.0147) | $0.0925^{***}$ (0.0217) | 0.1884 (0.1562) | $-0.0803^{***}$ (0.0251) | 1 | $4.6508^{***}$ (1.1950) | −12789.02 | 2.6733 | 6.55 |
| | $0.0267^{***}$ (0.0086) | $0.0182^{***}$ (0.0050) | $0.9188^{***}$ (0.0147) | $0.0925^{***}$ (0.0217) | 0.1921 (0.1558) | $-0.0823^{***}$ (0.0263) | 1.4895 (1.5532) | $5.8531^{*}$ (3.0656) | −12788.93 [0.6641] | 2.6742 | 6.90 |
| **Δ Ind. prod.** | $0.0266^{***}$ (0.0086) | $0.0174^{***}$ (0.0051) | $0.9180^{***}$ (0.0151) | $0.0933^{***}$ (0.0219) | 0.0769 (0.1375) | $-0.0434^{***}$ (0.0133) | 1 | $4.5453^{***}$ (1.2437) | −12788.47 | 2.6732 | 7.57 |
| | $0.0267^{***}$ (0.0086) | $0.0173^{***}$ (0.0051) | $0.9182^{***}$ (0.0152) | $0.0932^{***}$ (0.0219) | 0.0767 (0.1370) | $-0.0438^{***}$ (0.0129) | 1.6441 (1.3154) | $6.3975^{**}$ (3.2453) | −12788.25 [0.5064] | 2.6741 | 8.02 |
| **Δ Unemp.** | $0.0272^{***}$ (0.0086) | $0.0185^{***}$ (0.0050) | $0.9177^{***}$ (0.0150) | $0.0920^{***}$ (0.0218) | −0.0317 (0.1365) | $0.5689^{***}$ (0.1865) | 1 | $6.4943^{***}$ (2.1923) | −12789.96 | 2.6735 | 6.02 |
| | $0.0272^{***}$ (0.0086) | $0.0184^{***}$ (0.0050) | $0.9179^{***}$ (0.0150) | $0.0919^{***}$ (0.0218) | −0.0320 (0.1369) | $0.5751^{***}$ (0.1890) | 1.7441 (1.3159) | $9.4221^{*}$ (5.1010) | −12789.82 [0.5991] | 2.6744 | 6.30 |
| **Δ Housing** | $0.0269^{***}$ (0.0086) | $0.0205^{***}$ (0.0050) | $0.9141^{***}$ (0.0154) | $0.0932^{***}$ (0.0220) | 0.0736 (0.1383) | $-0.0159^{***}$ (0.0049) | 1 | $1.8226^{***}$ (0.2867) | −12782.79 | 2.6720 | 14.39 |
| | $0.0271^{***}$ (0.0086) | $0.0184^{***}$ (0.0049) | $0.9162^{***}$ (0.0152) | $0.0932^{***}$ (0.0216) | 0.0651 (0.1359) | $-0.0173^{***}$ (0.0047) | $2.8071^{**}$ (1.4305) | $4.8430^{*}$ (2.4845) | −12777.06 [0.0007] | 2.6718 | 21.85 |
| **Δ Corp. prof.** | $0.0263^{***}$ (0.0086) | $0.0174^{***}$ (0.0049) | $0.9188^{***}$ (0.0148) | $0.0936^{***}$ (0.0214) | 0.2249 (0.1550) | $-0.0187^{***}$ (0.0053) | 1 | $2.5114^{**}$ (1.0048) | −12783.30 | 2.6721 | 12.69 |
| | $0.0263^{***}$ (0.0086) | $0.0172^{***}$ (0.0051) | $0.9191^{***}$ (0.0150) | $0.0934^{***}$ (0.0215) | 0.2284 (0.1538) | $-0.0191^{***}$ (0.0057) | $1.1783^{**}$ (0.4851) | $2.8187^{**}$ (1.3902) | −12783.20 [0.6469] | 2.6730 | 13.24 |
| **Δ GDP deflator** | $0.0273^{***}$ (0.0086) | $0.0196^{***}$ (0.0049) | $0.9211^{***}$ (0.0143) | $0.0888^{***}$ (0.0213) | −0.1017 (0.1887) | 0.0269 (0.0259) | 1 | $3.5702^{***}$ (0.9506) | −12795.21 | 2.6746 | 0.99 |
| | $0.0274^{***}$ (0.0085) | $0.0189^{***}$ (0.0049) | $0.9220^{***}$ (0.0143) | $0.0888^{***}$ (0.0211) | −0.1385 (0.1751) | $0.0357^{*}$ (0.0194) | $114.1107^{***}$ (9.3931) | $197.1066^{***}$ (4.5289) | −12793.47 [0.0618] | 2.6752 | 2.10 |
| **NAI** | $0.0264^{***}$ (0.0086) | $0.0168^{***}$ (0.0052) | $0.9171^{***}$ (0.0151) | $0.0946^{***}$ (0.0219) | −0.0305 (0.1315) | $-0.3085^{***}$ (0.0728) | 1 | $7.7696^{**}$ (3.0232) | −12783.99 | 2.6722 | 12.84 |
| | $0.0264^{***}$ (0.0086) | $0.0168^{***}$ (0.0052) | $0.9171^{***}$ (0.0151) | $0.0946^{***}$ (0.0219) | −0.0305 (0.1315) | $-0.3081^{***}$ (0.0723) | 1.1506 (1.0892) | $8.4179^{**}$ (3.9454) | −12783.98 [0.8890] | 2.6732 | 12.86 |
| **New orders** | $0.0258^{***}$ (0.0086) | $0.0147^{***}$ (0.0053) | $0.9174^{***}$ (0.0149) | $0.0975^{***}$ (0.0217) | $2.6787^{***}$ (0.5637) | $-0.0496^{***}$ (0.0101) | 1 | $4.2905^{***}$ (1.5680) | −12776.96 | 2.6708 | 17.85 |
| | $0.0258^{***}$ (0.0086) | $0.0147^{***}$ (0.0053) | $0.9173^{***}$ (0.0149) | $0.0975^{***}$ (0.0218) | $2.6904^{***}$ (0.5563) | $-0.0498^{***}$ (0.0099) | 0.9392 (0.6626) | $4.1023^{***}$ (1.5572) | −12776.96 [0.9776] | 2.6717 | 17.85 |
| **Δ Cons. sent.** | $0.0270^{***}$ (0.0086) | $0.0194^{***}$ (0.0050) | $0.9158^{***}$ (0.0154) | $0.0935^{***}$ (0.0222) | −0.0175 (0.1361) | $-0.1141^{***}$ (0.0368) | 1 | $1.7135^{***}$ (0.2502) | −12789.08 | 2.6733 | 6.55 |
| | $0.0275^{***}$ (0.0085) | $0.0193^{***}$ (0.0050) | $0.9172^{***}$ (0.0151) | $0.0918^{***}$ (0.0218) | −0.0193 (0.1382) | $-0.1335^{***}$ (0.0338) | $2.4732^{***}$ (0.6649) | $4.0434^{**}$ (1.6654) | −12783.04 [0.0005] | 2.6730 | 12.63 |
| **Δ real cons.** | $0.0265^{***}$ (0.0086) | $0.0191^{***}$ (0.0049) | $0.9179^{***}$ (0.0146) | $0.0932^{***}$ (0.0219) | 0.2952 (0.2041) | $-0.0992^{**}$ (0.0422) | 1 | $3.6582^{***}$ (1.1263) | −12791.11 | 2.6737 | 5.04 |
| | $0.0270^{***}$ (0.0085) | $0.0195^{***}$ (0.0049) | $0.9188^{***}$ (0.0146) | $0.0911^{***}$ (0.0219) | $0.3406^{*}$ (0.1998) | $-0.1161^{***}$ (0.0413) | 2.6571 (1.9264) | $8.5625^{*}$ (4.8275) | −12789.50 [0.0731] | 2.6743 | 7.70 |
| **Term spread** | $0.0276^{***}$ (0.0085) | $0.0192^{***}$ (0.0050) | $0.9144^{***}$ (0.0162) | $0.0919^{***}$ (0.0226) | $0.4155^{***}$ (0.1482) | $-0.2723^{***}$ (0.0554) | 1 | $1.6276^{***}$ (0.5485) | −12779.46 | 2.6713 | 14.32 |
| | $0.0272^{***}$ (0.0085) | $0.0182^{***}$ (0.0050) | $0.9144^{***}$ (0.0164) | $0.0930^{***}$ (0.0229) | $0.3658^{***}$ (0.1388) | $-0.2443^{***}$ (0.0458) | $4.2018^{*}$ (2.4167) | $6.2756^{**}$ (3.0765) | −12777.47 [0.0463] | 2.6718 | 15.94 |
| **RV** | $0.0272^{***}$ (0.0085) | $0.0203^{***}$ (0.0049) | $0.9053^{***}$ (0.0259) | $0.1012^{***}$ (0.0308) | $-0.2761^{**}$ (0.1203) | $0.0033^{***}$ (0.0009) | 1 | 3.7869 (6.7929) | −12785.29 | 2.6725 | 12.96 |
| | $0.0271^{***}$ (0.0085) | $0.0205^{***}$ (0.0049) | $0.9040^{***}$ (0.0194) | $0.1021^{***}$ (0.0260) | $-0.2956^{**}$ (0.1167) | $0.0036^{***}$ (0.0010) | 0.5746 (0.6140) | 2.3646 (2.3155) | −12784.90 [0.3800] | 2.6734 | 13.74 |
| **GARCH(1,1)** | $0.0275^{***}$ (0.0086) | $0.0200^{***}$ (0.0048) | $0.9215^{***}$ (0.0142) | $0.0878^{***}$ (0.0211) | 0.0049 (0.1553) | - | - | - | −12796.04 | 2.6728 | - |

**Notes:** The table reports estimation results for the one-sided GARCH-MIDAS-X models including 3 MIDAS lag years of a quarterly macro variable $X$, i.e, the long-run component is specified as

$$\log(\tau_t^X) = m + \theta \cdot \sum_{k=1}^{K} \varphi_k(\omega_1, \omega_2) X_{t-k},$$

with $K = 12$. All estimations are based on daily return data from 1973Q1 to 2010Q4 and include quarterly macroeconomic data from 1970Q1 on. The numbers in parentheses are Bollerslev-Wooldridge robust standard errors. $^{***}$, $^{**}$, $^{*}$ indicate significance at the 1%, 5%, and 10% level. We estimate each model with a restricted ($\omega_1 = 1$) and an unrestricted weighting scheme. LLF is the value of the maximized log-likelihood function. The numbers in brackets are $p$-values from a likelihood ratio test $2(L_{UR} - L_R)$, where $L_{UR}$ and $L_R$ refer to the likelihood of the GARCH-MIDAS-X models with unrestricted and restricted weights, respectively. BIC is the Bayesian information criterion and VR(X) denotes the variance ratio statistic, see Eq. (9).

Table A.2: One- and two-sided GARCH-MIDAS-X specifications

| Variable | $K_{lag}$ | $K_{lead}$ | $m$ | $\theta$ | $\omega_1$ | $\omega_2$ | LLF | BIC | VR(X) |
|---|---|---|---|---|---|---|---|---|---|
| **Δ real GDP** | 12 | - | 0.1884 (0.1562) | $-0.0803^{***}$ (0.0251) | 1 | $4.6508^{***}$ (1.1950) | −12789.02 | 2.6733 | 6.55 |
| **Δ real GDP** | 12 | 3 | $0.3088^{*}$ (0.1598) | $-0.1327^{***}$ (0.0336) | $8.1523^{***}$ (2.3815) | $4.2075^{***}$ (1.1460) | −12784.50 | 2.6733 | 12.88 |
| **Δ real GDP** | 12 | $3^{(TSF)}$ | 0.2454 (0.1620) | $-0.1044^{***}$ (0.0289) | $8.5411^{***}$ (2.8274) | $4.7078^{*}$ (2.7246) | −12787.47 | 2.6739 | 7.93 |
| **Δ real GDP (*)** | 12 | $2^{(SPF)}$ | $0.3684^{*}$ (0.1973) | $-0.1475^{***}$ (0.0443) | $5.6729^{***}$ (1.6418) | $2.1630^{**}$ (0.9840) | −12785.73 | 2.6736 | 9.76 |
| **Δ real GDP (*)** | $12^{(SPF)}$ | $2^{(SPF)}$ | $0.3714^{**}$ (0.1749) | $-0.1658^{***}$ (0.0389) | $9.3371^{**}$ (4.3608) | $3.8444^{**}$ (1.7972) | −12780.21 | 2.6724 | 14.08 |
| **Δ Ind. prod.** | 12 | - | 0.0769 (0.1375) | $-0.0434^{***}$ (0.0133) | 1 | $4.5453^{***}$ (1.2437) | −12788.47 | 2.6732 | 7.57 |
| **Δ Ind. prod.** | 12 | 3 | 0.1522 (0.1288) | $-0.0825^{***}$ (0.0188) | $7.6085^{***}$ (2.2601) | $3.9072^{***}$ (0.9991) | −12780.76 | 2.6725 | 18.19 |
| **Δ Ind. prod.** | 12 | $3^{(TSF)}$ | 0.0975 (0.1372) | $-0.0544^{***}$ (0.0144) | $10.7031^{***}$ (3.4036) | $6.2838^{**}$ (2.6072) | −12786.64 | 2.6738 | 9.45 |
| **Δ Ind. prod.** | 12 | $3^{(SPF)}$ | $0.4512^{*}$ (0.2676) | $-0.1578^{***}$ (0.0611) | $3.6772^{***}$ (1.3667) | 1.3264 (0.8758) | −12781.27 | 2.6726 | 15.26 |
| **Δ Ind. prod.** | $12^{(SPF)}$ | $3^{(SPF)}$ | 0.3950 (0.3425) | $-0.1418^{*}$ (0.0811) | 4.2192 (3.5359) | 1.8766 (2.2438) | −12783.03 | 2.6730 | 12.10 |
| **Δ Unemp.** | 12 | - | −0.0317 (0.1365) | $0.5689^{***}$ (0.1865) | 1 | $6.4943^{***}$ (2.1923) | −12789.96 | 2.6735 | 6.02 |
| **Δ Unemp.** | 12 | 3 | −0.0596 (0.1242) | $1.2381^{***}$ (0.2763) | $9.7239^{**}$ (4.3270) | $3.6440^{**}$ (1.4595) | −12780.53 | 2.6725 | 20.18 |
| **Δ Unemp.** | 12 | $3^{(TSF)}$ | −0.0356 (0.1363) | $0.6837^{***}$ (0.1999) | $13.5712^{***}$ (4.7068) | $6.8646^{**}$ (3.4311) | −12789.68 | 2.6744 | 6.39 |
| **Δ Unemp.** | 12 | $3^{(SPF)}$ | −0.0132 (0.1298) | $2.7466^{***}$ (0.7783) | $4.3472^{***}$ (1.3590) | $1.1997^{**}$ (0.5743) | −12780.62 | 2.6725 | 15.62 |
| **Δ Unemp.** | $12^{(SPF)}$ | $3^{(SPF)}$ | −0.0629 (0.1358) | $2.3487^{***}$ (0.7288) | $4.8550^{***}$ (1.8725) | $1.5961^{*}$ (0.8928) | −12782.30 | 2.6728 | 12.71 |
| **Δ Housing** | 12 | - | 0.0651 (0.1359) | $-0.0173^{***}$ (0.0047) | $2.8071^{**}$ (1.4305) | $4.8430^{*}$ (2.4845) | −12777.06 | 2.6718 | 21.85 |
| **Δ Housing** | 12 | 3 | 0.0648 (0.1344) | $-0.0175^{***}$ (0.0046) | $7.2945^{***}$ (2.6925) | $7.4350^{***}$ (2.8725) | −12777.19 | 2.6718 | 22.15 |
| **Δ Housing** | 12 | $3^{(TSF)}$ | 0.0659 (0.1349) | $-0.0177^{***}$ (0.0046) | $7.1303^{**}$ (3.1926) | $7.1905^{**}$ (3.3751) | −12776.97 | 2.6717 | 22.30 |
| **Δ Housing** | 12 | $3^{(SPF)}$ | 0.0693 (0.1367) | $-0.0184^{***}$ (0.0055) | $6.8567^{*}$ (3.5110) | $6.8895^{*}$ (3.6895) | −12776.81 | 2.6717 | 22.82 |
| **Δ Housing** | $12^{(SPF)}$ | $3^{(SPF)}$ | −0.1033 (0.1294) | $-0.0210^{***}$ (0.0065) | 3.6753 (2.9977) | 5.2542 (3.4620) | −12783.73 | 2.6731 | 10.93 |
| **Δ Corp. prof.** | 12 | - | 0.2249 (0.1550) | $-0.0187^{***}$ (0.0053) | 1 | $2.5114^{**}$ (1.0048) | −12783.30 | 2.6721 | 12.69 |
| **Δ Corp. prof.** | 12 | 3 | $0.2849^{*}$ (0.1552) | $-0.0237^{***}$ (0.0062) | 4.4428 (3.5278) | $3.4230^{**}$ (1.7327) | −12781.71 | 2.6727 | 16.23 |
| **Δ Corp. prof. (*)** | 12 | $2^{(TSF)}$ | 0.2595 (0.1622) | $-0.0217^{***}$ (0.0059) | $3.7175^{*}$ (2.0642) | $2.6406^{**}$ (1.2702) | −12784.31 | 2.6733 | 12.50 |
| **Δ Corp. prof.** | 12 | $3^{(SPF)}$ | $0.3130^{*}$ (0.1660) | $-0.0289^{***}$ (0.0076) | $3.4713^{*}$ (1.9386) | $2.3592^{**}$ (0.9464) | −12781.60 | 2.6727 | 15.46 |
| **Δ Corp. prof.** | $12^{(SPF)}$ | $3^{(SPF)}$ | 0.2318 (0.1581) | $-0.0440^{***}$ (0.0120) | $6.2270^{**}$ (2.5411) | $3.7382^{**}$ (1.5118) | −12778.57 | 2.6721 | 15.96 |
| **Δ GDP deflator** | 12 | - | −0.1385 (0.1751) | $0.0357^{*}$ (0.0194) | $114.1107^{***}$ (9.3931) | $197.1066^{***}$ (4.5289) | −12793.47 | 2.6752 | 2.10 |
| **Δ GDP deflator** | 12 | 3 | −0.1394 (0.1754) | $0.0358^{*}$ (0.0192) | $185.7127^{***}$ (4.8179) | $202.5811^{***}$ (4.3104) | −12793.48 | 2.6752 | 2.08 |
| **Δ GDP deflator** | 12 | $3^{(TSF)}$ | −0.1318 (0.1746) | $0.0341^{*}$ (0.0184) | $344.4171^{***}$ (2.5678) | $403.7092^{***}$ (1.7643) | −12793.48 | 2.6752 | 1.96 |
| **Δ GDP deflator** | 12 | $3^{(SPF)}$ | −0.1390 (0.1753) | $0.0358^{*}$ (0.0193) | $218.7094^{***}$ (6.6379) | $236.9913^{***}$ (6.5734) | −12793.47 | 2.6752 | 2.11 |
| **Δ GDP deflator** | $12^{(SPF)}$ | $3^{(SPF)}$ | −0.1642 (0.1838) | 0.0408 (0.0255) | $399.3586^{***}$ (3.9616) | $388.1800^{***}$ (3.8229) | −12794.12 | 2.6753 | 2.10 |
| **GARCH(1,1)** | - | - | 0.0049 (0.1553) | - | - | - | −12796.04 | 2.6728 | - |

**Notes:** The table compares estimation results for the one- and two-sided GARCH-MIDAS-X specifications,

$$\log(\tau_t) = m + \theta \sum_{k=1}^{K_{lag}} \varphi_k(\omega_1, \omega_2) X_{t-k},$$

$$\log(\tau_t) = m + \theta \sum_{k=1}^{K_{lag}} \varphi_k(\omega_1, \omega_2) X_{t-k} + \theta \sum_{k=-K_{lead}}^{0} \varphi_k(\omega_1, \omega_2) \tilde{X}_{t-k},$$

with $K_{lag} = 12$ and $K_{lead} = 3$. All estimations are based on daily return data from 1973Q1 to 2010Q4 and quarterly macroeconomic data from 1970Q1 on. We include a restricted weighting scheme ($\omega_1 = 1$) in the one-sided filter for all variables except for housing starts and the GDP deflator. The infeasible two-sided filter includes leads of the realized macro variable, i.e. $\tilde{X}_{t-k} = X_{t-k}$, whereas feasible filters are based on time series (TSF) or survey forecasts (SPF), i.e. $\tilde{X}_{t-k} = X^{TSF}_{t-k|t-1}$ or $\tilde{X}_{t-k} = X^{SPF}_{t-k|t-1}$. Finally, we consider a specification which is entirely based on SPF data, see Eq. (13). Otherwise, see the notes of Table A.1.
(*) Due to convergence problems for $K_{lead} = 3$, we choose $K_{lead} = 2$ for these specifications.

Table A.3: Quarterly RV Forecasting - GARCH-MIDAS-RV-X models

| **Forecast horizon** | **1-quarter-ahead** | | | | **2-quarters-ahead** | | | | **3-quarters-ahead** | | | | **4-quarters-ahead** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **MZ-Regression** | | | **MSE** | **MZ-Regression** | | | **MSE** | **MZ-Regression** | | | **MSE** | **MZ-Regression** | | | **MSE** |
| **Variable** | $c$ | $\phi$ | $R^2$ | **ratio** | $c$ | $\phi$ | $R^2$ | **ratio** | $c$ | $\phi$ | $R^2$ | **ratio** | $c$ | $\phi$ | $R^2$ | **ratio** |
| **RV + Δ real GDP** | 0.51 (17.00) | 0.86 (0.23) | 58.64 | 1.20 [0.25] | 86.93 (34.30) | 0.05 (0.15) | 0.06 | 1.08 [0.25] | 101.39 (39.57) | −0.12 (0.16) | 0.38 | 1.07 [0.32] | 103.11 (40.85) | −0.15 (0.19) | 0.53 | 1.06 [0.30] |
| **RV + Δ Ind. prod.** | 7.87 (17.87) | 0.74 (0.25) | 51.70 | 1.56 [0.24] | 88.62 (33.43) | 0.03 (0.11) | 0.03 | 1.24 [0.27] | 99.75 (37.91) | −0.09 (0.13) | 0.37 | 1.22 [0.28] | 100.33 (38.67) | −0.10 (0.15) | 0.42 | 1.21 [0.26] |
| **RV + Δ Unemp.** | 2.55 (17.63) | 0.81 (0.24) | 56.29 | 1.33 [0.27] | 86.63 (33.61) | 0.05 (0.13) | 0.09 | 1.16 [0.28] | 99.79 (38.89) | −0.09 (0.14) | 0.33 | 1.16 [0.29] | 101.04 (39.31) | −0.11 (0.16) | 0.44 | 1.15 [0.26] |
| **RV + Δ Housing (ur)** | −29.83 (18.36) | 1.32 (0.25) | 71.64 | 0.89 [0.58] | 59.37 (35.70) | 0.42 (0.38) | 1.38 | 0.88 [0.11] | 78.58 (38.36) | 0.17 (0.38) | 0.20 | **0.86** [0.06] | 90.27 (40.31) | 0.01 (0.29) | 0.00 | **0.87** [0.06] |
| **RV + Δ Corp. prof.** | 37.56 (12.65) | 0.46 (0.13) | 39.41 | 3.22 [0.31] | 79.82 (28.80) | 0.11 (0.08) | 1.21 | 1.52 [0.35] | 89.46 (31.34) | 0.02 (0.09) | 0.03 | 1.54 [0.37] | 92.12 (32.27) | −0.01 (0.08) | 0.01 | 1.56 [0.36] |
| **RV + Δ GDP deflator (ur)** | −6.31 (15.46) | 1.02 (0.22) | 65.70 | 0.94 [0.52] | 83.78 (36.51) | 0.10 (0.21) | 0.14 | 0.98 [0.59] | 106.65 (44.96) | −0.21 (0.26) | 0.59 | 0.97 [0.49] | 109.67 (46.33) | −0.26 (0.30) | 0.85 | 0.97 [0.47] |
| **RV + NAI** | 13.44 (15.78) | 0.65 (0.20) | 53.47 | 1.82 [0.28] | 85.69 (30.62) | 0.05 (0.09) | 0.19 | 1.41 [0.29] | 97.01 (34.77) | −0.06 (0.09) | 0.22 | 1.41 [0.29] | 98.27 (35.93) | −0.07 (0.10) | 0.33 | 1.40 [0.27] |
| **RV + new orders** | 21.74 (13.96) | 0.60 (0.20) | 46.59 | 2.10 [0.25] | 86.76 (30.91) | 0.04 (0.09) | 0.14 | 1.44 [0.28] | 96.15 (34.48) | −0.05 (0.09) | 0.19 | 1.43 [0.28] | 97.05 (35.49) | −0.06 (0.10) | 0.26 | 1.42 [0.27] |
| **RV + Δ Cons. sent. (ur)** | 34.36 (12.94) | 0.45 (0.14) | 34.53 | 3.43 [0.25] | 83.75 (28.60) | 0.07 (0.07) | 0.44 | 1.66 [0.30] | 94.90 (31.37) | −0.03 (0.06) | 0.12 | 1.67 [0.30] | 97.70 (32.61) | −0.06 (0.07) | 0.35 | 1.66 [0.29] |
| **RV + Δ real cons.(ur)** | 11.27 (13.29) | 0.72 (0.17) | 60.73 | 1.37 [0.33] | 82.62 (30.74) | 0.09 (0.12) | 0.35 | 1.14 [0.29] | 99.90 (36.33) | −0.10 (0.12) | 0.36 | 1.14 [0.29] | 102.00 (37.65) | −0.13 (0.15) | 0.55 | 1.14 [0.27] |
| **RV + Term spread (ur)** | 34.97 (12.42) | 0.51 (0.16) | 37.49 | 2.68 [0.28] | 85.28 (29.69) | 0.06 (0.07) | 0.34 | 1.59 [0.31] | 93.20 (31.26) | −0.02 (0.07) | 0.04 | 1.61 [0.33] | 94.45 (31.78) | −0.03 (0.07) | 0.11 | 1.59 [0.34] |
| **RV** | −6.76 (15.75) | 0.92 (0.20) | 64.99 | 1 | 82.18 (36.48) | 0.10 (0.19) | 0.20 | 1 | 107.83 (46.38) | −0.20 (0.25) | 0.67 | 1 | 112.28 (48.19) | −0.26 (0.29) | 1.06 | 1 |
| **GARCH(1,1)** | −20.96 (13.49) | 1.30 (0.18) | 78.88 | 0.69 [0.26] | 7.43 (26.05) | 1.25 (0.26) | 8.11 | 0.83 [0.15] | 5.00 (63.79) | 1.43 (0.98) | 1.44 | 0.84 [0.15] | 26.33 (175.36) | 1.12 (2.93) | 0.12 | 0.86 [0.15] |

**Notes:** We estimate all one-sided GARCH-MIDAS-RV-X models based on daily return data from 1973Q1 to 1998Q4 and quarterly macroeconomic data from 1970Q1 on. We then compare quarterly volatility forecasts over the 2000Q1-2010Q4 period for varying forecast horizons, $h = 1, 2, 3, 4$, corresponding to one-quarter- up to four-quarters-ahead forecasts. This out-of-sample period consists of 44 quarterly observations. For each horizon we evaluate the forecasts via a Mincer-Zarnowitz-Regression

$$RV_t = c + \phi \cdot \widehat{RV}_{t|t-h} + \xi_t, \quad \text{with } \widehat{RV}_{t|t-h} = \sum_{i=1}^{N^{(t)}} \hat{g}_{i,t|t-h} \cdot \hat{\tau}_{t|t-h}, \quad \text{for } h = 1, \ldots, 4,$$

using robust standard errors. $RV_t$ denotes the quarterly realized variance, calculated as the sum of daily realized variances based on 5-minute intra-day returns over one quarter. We report parameter estimates for $c$ and $\phi$ with standard errors in parentheses, as well as the $R^2$ percentage value. Finally, we compute MSE-ratios relative to the GARCH-MIDAS-RV model. A ratio smaller than one indicates an improvement over this benchmark model. In brackets we report $p$-values from the respective Giacomini-White-Test. Bold MSE ratios indicate cases in which the respective $p$-value is less or equal than 10%.

Table A.4: Principal components - correlation structure

| **Correlation with** | Δ real GDP | Δ Ind. prod. | Δ Unemp. | Δ Housing | Δ Corp. prof. | GDP deflator | NAI | New orders | Δ Cons. sent. | Δ real cons. | Term spread |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PC 1** | 0.91 | 0.88 | -0.85 | 0.31 | 0.42 | -0.28 | 0.92 | 0.89 | 0.35 | 0.68 | 0.24 |
| **PC 2** | -0.03 | -0.27 | 0.27 | 0.37 | 0.24 | -0.56 | -0.25 | -0.06 | 0.39 | 0.10 | 0.81 |

**Notes:** We compute the first two principal components of our macroeconomic dataset (1969Q1-2011Q4) and present their correlations with each of the macro variable. The first principal component accounts for 45 percent and the second one for 14 percent of the variation in our variables.

Table A.5: Principal components - one-sided GARCH-MIDAS-X specifications

| **Variable** | $m$ | $\theta^{RV}$ | $w_2^{RV}$ | $\theta^{X}$ | $w_1^{X}$ | $w_2^{X}$ | LLF | BIC | VR(X) |
|---|---|---|---|---|---|---|---|---|---|
| **PC 1** | $-0.0229$ | - | - | $-0.1516^{***}$ | 1 | $4.5971^{***}$ | $-12782.05$ | 2.6718 | 13.19 |
| | (0.1304) | | | (0.0322) | | (1.1558) | | | |
| | $-0.0236$ | - | - | $-0.1504^{***}$ | 1.5591 | $6.3095^{**}$ | $-12781.84$ | 2.6728 | 13.54 |
| | (0.1309) | | | (0.0309) | (0.9572) | (2.8480) | [0.5195] | | |
| **RV + PC 1** | $-0.2263^{**}$ | $0.0024^{***}$ | 6.2793 | $-0.1104^{***}$ | 1 | $5.4296^{**}$ | $-12774.52$ | 2.6722 | 23.36 |
| | (0.1097) | (0.0008) | (8.7899) | (0.0350) | | (2.2506) | | | |
| | $-0.2239^{**}$ | $0.0023^{***}$ | 6.6836 | $-0.1110^{***}$ | 1.3897 | $6.6348^{*}$ | $-12774.47$ | 2.6731 | 23.59 |
| | (0.1082) | (0.0008) | (7.6584) | (0.0345) | (1.3868) | (3.3924) | [0.7511] | | |
| **PC 2** | $-0.0311$ | - | - | $-0.2698^{***}$ | 1 | $1.1920^{***}$ | $-12784.34$ | 2.6723 | 9.72 |
| | (0.1354) | | | (0.0585) | | (0.3445) | | | |
| | $-0.0371$ | - | - | $-0.2563^{***}$ | 4.4983 | 4.8846 | $-12781.07$ | 2.6726 | 12.78 |
| | (0.1313) | | | (0.0545) | (5.1288) | (5.6169) | [0.0106] | | |
| **RV + PC 2** | $-0.4086^{***}$ | $0.0046^{***}$ | 2.5985 | $-0.2974^{***}$ | 1 | $1.6937^{***}$ | $-12764.32$ | 2.6701 | 25.75 |
| | (0.1285) | (0.0014) | (2.0335) | (0.0623) | | (0.4617) | | | |
| | $-0.4235^{***}$ | $0.0048^{***}$ | $2.1655^{*}$ | $-0.2824^{***}$ | $4.2344^{*}$ | $6.5692^{**}$ | $-12760.36$ | 2.6702 | 28.13 |
| | (0.1300) | (0.0014) | (1.1671) | (0.0553) | (2.2723) | (3.1515) | [0.0049] | | |
| **GARCH(1,1)** | 0.0049 | - | - | - | - | - | $-12796.04$ | 2.6728 | - |
| | (0.1553) | | | | | | | | |

**Notes:** The one-sided GARCH-MIDAS-X and GARCH-MIDAS-RV-X models are estimated inlcuding the first two principal components of all macro variables. The estimations are based on daily return data from 1973Q1 to 2010Q4 and include quarterly macroeconomic data from 1970Q1 on. Otherwise, see the notes of Table A.1.

Table A.6: Principal components - quarterly RV forecasting

| **Forecast horizon** | **1-q ahead** | | | | **2-q ahead** | | | | **3-q ahead** | | | | **4-q ahead** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **MZ-Regression** | | | **MSE** | **MZ-Regression** | | | **MSE** | **MZ-Regression** | | | **MSE** | **MZ-Regression** | | | **MSE** |
| **Variable** | $c$ | $\beta$ | $R^2$ | **ratio** | $c$ | $\beta$ | $R^2$ | **ratio** | $c$ | $\beta$ | $R^2$ | **ratio** | $c$ | $\beta$ | $R^2$ | **ratio** |
| **PC 1** | $-19.12$ | 1.30 | 79.18 | 0.69 | $-0.38$ | 1.41 | 9.45 | 0.82 | 8.07 | 1.39 | 3.25 | 0.83 | 21.74 | 1.18 | 1.78 | **0.84** |
| | (13.04) | (0.17) | | [0.25] | (30.18) | (0.53) | | [0.13] | (64.71) | (1.18) | | [0.11] | (66.28) | (1.16) | | [0.10] |
| **RV + PC 1** | 7.69 | 0.77 | 53.82 | 1.44 | 85.49 | 0.06 | 0.16 | 1.20 | 96.89 | $-0.06$ | 0.17 | 1.19 | 98.18 | $-0.08$ | 0.26 | 1.19 |
| | (16.70) | (0.23) | | [0.25] | (31.89) | (0.12) | | [0.30] | (36.09) | (0.12) | | [0.32] | (37.12) | (0.13) | | [0.30] |
| **PC 2 (ur)** | $-34.53$ | 1.83 | 81.02 | 1.05 | $-85.55$ | 3.45 | 19.79 | 0.86 | $-156.97$ | 5.08 | 21.70 | 0.83 | $-206.41$ | 6.08 | 26.09 | **0.83** |
| | (14.54) | (0.22) | | [0.90] | (39.37) | (0.98) | | [0.20] | (85.68) | (2.05) | | [0.12] | (93.47) | (2.21) | | [0.08] |
| **RV + PC 2 (ur)** | 46.57 | 0.41 | 35.99 | 3.81 | 85.27 | 0.07 | 0.50 | 1.75 | 92.72 | $-0.02$ | 0.04 | 1.78 | 94.31 | $-0.04$ | 0.15 | 1.78 |
| | (12.99) | (0.12) | | [0.31] | (28.30) | (0.05) | | [0.31] | (29.51) | (0.05) | | [0.32] | (30.00) | (0.05) | | [0.33] |

**Notes:** We estimate the one-sided GARCH-MIDAS-X models including the first two principal components based on daily return data from 1973Q1 to 1998Q4 and quarterly macroeconomic data from 1970Q1 on and compare quarterly volatility forecasts over the 2000Q1-2010Q4 period for varying forecast horizons. Otherwise, see the notes of Table A.3.

Table A.7: One-sided GARCH-MIDAS-X specifications - including uncertainty measures

| Variable | $m$ | $\theta$ | $\omega_2$ | LLF | BIC | VR(X) |
|---|---|---|---|---|---|---|
| **Δ real GDP - vola** | −0.0738 | 0.0362 | 4.5674** | −12795.58 | 2.6747 | 0.42 |
| | (0.1961) | (0.0494) | (1.8726) | | | |
| **Δ real GDP - disp(t)** | −0.1399 | 0.0967 | 5.7121*** | −12794.88 | 2.6745 | 1.04 |
| | (0.1827) | (0.0733) | (1.6940) | | | |
| **Δ real GDP - disp(t+1)** | −0.2502 | 0.1654** | 12.7999 | −12791.49 | 2.6738 | 3.36 |
| | (0.1701) | (0.0654) | (9.1566) | | | |
| **Δ real GDP - disp(t+2)** | −0.3228* | 0.2166*** | 7.3951** | −12788.69 | 2.6732 | 5.36 |
| | (0.1733) | (0.0677) | (3.0943) | | | |
| **Δ real GDP - disp(t+3)** | −0.2629 | 0.1860** | 7.6622* | −12791.45 | 2.6738 | 3.40 |
| | (0.1854) | (0.0771) | (4.4139) | | | |
| **Δ real GDP - disp(t+4)** | −0.1485 | 0.1034 | 3.1003*** | −12794.67 | 2.6745 | 1.21 |
| | (0.1923) | (0.0794) | (0.9693) | | | |
| **Δ Ind. prod. - vola** | −0.0093 | 0.0036 | 84.8578*** | −12795.93 | 2.6747 | 0.05 |
| | (0.1569) | (0.0095) | (0.0863) | | | |
| **Δ Ind. prod. - disp(t)** | −0.1023 | 0.0303 | 93.2056*** | −12794.37 | 2.6744 | 0.77 |
| | (0.1830) | (0.0273) | (0.0401) | | | |
| **Δ Ind. prod. - disp(t+1)** | −0.2087 | 0.0679** | 24.4823*** | −12791.30 | 2.6738 | 2.89 |
| | (0.1567) | (0.0271) | (8.7081) | | | |
| **Δ Ind. prod. - disp(t+2)** | −0.1649 | 0.0557 | 28.3161*** | −12791.72 | 2.6739 | 2.62 |
| | (0.1757) | (0.0361) | (9.1895) | | | |
| **Δ Ind. prod. - disp(t+3)** | −0.1998 | 0.0700* | 3.8946*** | −12793.32 | 2.6742 | 2.12 |
| | (0.1887) | (0.0393) | (1.1607) | | | |
| **Δ Ind. prod. - disp(t+4)** | −0.3326 | 0.1194* | 3.3750** | −12790.27 | 2.6736 | 4.51 |
| | (0.2305) | (0.0663) | (1.3762) | | | |
| **Unemp. - vola** | −0.0152 | 0.0837 | 96.8312*** | −12795.85 | 2.6747 | 0.08 |
| | (0.1642) | (0.1781) | (0.1480) | | | |
| **Unemp. - disp(t)** | −0.1347 | 0.8437 | 7.2600** | −12794.79 | 2.6745 | 0.98 |
| | (0.1863) | (0.6182) | (3.3421) | | | |
| **Unemp. - disp(t+1)** | −0.4200* | 1.6465** | 6.5758*** | −12790.10 | 2.6735 | 4.46 |
| | (0.2357) | (0.7093) | (1.9051) | | | |
| **Unemp. - disp(t+2)** | −0.4969** | 1.3964*** | 4.7422*** | −12788.99 | 2.6733 | 5.74 |
| | (0.2085) | (0.4236) | (1.0817) | | | |
| **Unemp. - disp(t+3)** | −0.5178*** | 1.1970*** | 7.8313* | −12783.92 | 2.6722 | 7.66 |
| | (0.1934) | (0.2764) | (4.5198) | | | |
| **Unemp. - disp(t+4)** | −0.4967*** | 0.9941*** | 6.3622*** | −12785.04 | 2.6725 | 7.02 |
| | (0.1837) | (0.2264) | (2.4066) | | | |
| **Δ Housing - vola** | 0.1560 | −0.0051 | 1.0770 | −12795.17 | 2.6746 | 1.11 |
| | (0.2642) | (0.0067) | (0.9358) | | | |
| **Δ Housing - disp(t)** | −0.0398 | 0.0020 | 8.1061** | −12795.96 | 2.6747 | 0.8 |
| | (0.2105) | (0.0065) | (3.9674) | | | |
| **Δ Housing - disp(t+1)** | −0.1768 | 0.0083 | 8.7074 | −12793.60 | 2.6742 | 2.80 |
| | (0.1910) | (0.0051) | (7.8799) | | | |
| **Δ Housing - disp(t+2)** | −0.2482* | 0.0124*** | 138.7290*** | −12787.84 | 2.6730 | 6.22 |
| | (0.1499) | (0.0036) | (1.3050) | | | |
| **Δ Housing - disp(t+3)** | −0.2673 | 0.0144*** | 8.2040** | −12790.53 | 2.6736 | 5.31 |
| | (0.1695) | (0.0051) | (3.6190) | | | |
| **Δ Housing - disp(t+4)** | −0.1581 | 0.0096 | 9.6938 | −12794.35 | 2.6744 | 1.69 |
| | (0.1984) | (0.0077) | (8.7115) | | | |
| **Δ Corp. prof. - vola** | 0.0375 | −0.0016 | 117.7321*** | −12795.28 | 2.6746 | 0.30 |
| | (0.1642) | (0.0015) | (0.0776) | | | |
| **Δ Corp. prof. - disp(t)** | 0.6851** | −0.0437** | 1.0528*** | −12788.08 | 2.6731 | 8.21 |
| | (0.3137) | (0.0180) | (0.3920) | | | |
| **Δ Corp. prof. - disp(t+1)** | −0.2247 | 0.0167 | 7.2212** | −12794.60 | 2.6745 | 1.41 |
| | (0.2479) | (0.0152) | (3.0518) | | | |
| **Δ Corp. prof. - disp(t+2)** | −0.0040 | 0.0007 | 12.0173* | −12796.02 | 2.6748 | 0.01 |
| | (0.1639) | (0.0037) | (6.9746) | | | |
| **Δ Corp. prof. - disp(t+3)** | 0.0264 | −0.0018 | 82.5353*** | −12795.81 | 2.6747 | 0.09 |
| | (0.1592) | (0.0028) | (0.0420) | | | |
| **Δ Corp. prof. - disp(t+4)** | −0.4596 | 0.0422* | 3.6093*** | −12792.20 | 2.6740 | 3.94 |
| | (0.2935) | (0.0238) | (1.3483) | | | |
| **Δ GDP deflator - vola** | −0.0705 | 0.0739 | 4.4783** | −12795.60 | 2.6747 | 0.49 |
| | (0.1728) | (0.0952) | (2.2468) | | | |
| **Δ GDP deflator - disp(t)** | −0.1677 | 0.1605 | 109.9414*** | −12793.95 | 2.6743 | 1.27 |
| | (0.1765) | (0.1024) | (0.1224) | | | |
| **Δ GDP deflator - disp(t+1)** | −0.1909 | 0.2033 | 6.0606** | −12795.05 | 2.6745 | 1.13 |
| | (0.2614) | (0.2039) | (2.6030) | | | |
| **Δ GDP deflator - disp(t+2)** | −0.3210 | 0.3259* | 3.7749** | −12793.13 | 2.6741 | 3.36 |
| | (0.2409) | (0.1850) | (1.7386) | | | |
| **Δ GDP deflator - disp(t+3)** | −0.0217 | 0.0273 | 59.1361*** | −12795.99 | 2.6747 | 0.03 |
| | (0.1959) | (0.1298) | (0.0653) | | | |
| **Δ GDP deflator - disp(t+4)** | −0.2581 | 0.2525* | 13.1151* | −12793.19 | 2.6742 | 2.26 |
| | (0.2127) | (0.1520) | (7.3896) | | | |
| **GARCH(1,1)** | 0.0049 | - | - | −12796.04 | 2.6728 | - |
| | (0.1553) | | | | | |

**Notes:** The table reports estimation results for the one-sided GARCH-MIDAS-X models including 3 MIDAS lag years of a macro uncertainty measure with a restricted weighting scheme, i.e, the long-run component is specified as

$$\log(\tau_t^X) = m + \theta \cdot \sum_{k=1}^{K} \varphi_k(1, \omega_2) X_{t-k},$$

with $K = 12$. Measures of macroeconomic uncertainty are either based on proxies for macro volatilities, see Eq. (8), or on cross-sectional measures of forecast dispersion from the SPF. The latter are available for the current quarter (disp(t)) and up to four-quarters-ahead (disp(t+4)). For the unemployment rate, the uncertainty measures refer to the level of the variable. Otherwise, see the notes of Table A.1.

Table A.8: Predictive regressions

| Variable (Model) | $\Delta R^2$ | c | $\rho$ | $\theta$ |
|---|---|---|---|---|
| **Panel A** | | | | |
| **Δ real GDP** | 0.06 | $0.6443^{***}$ (0.1305) | $0.6766^{***}$ (0.0621) | $-0.0030$ (0.0075) |
| **Δ Ind. prod.** | 0.13 | $0.6503^{***}$ (0.1277) | $0.6723^{***}$ (0.0625) | $-0.0022$ (0.0036) |
| **Δ Unemp.** | 0.25 | $0.6634^{***}$ (0.1282) | $0.6624^{***}$ (0.0645) | 0.0553 (0.0653) |
| **Δ Housing** | 0.38 | $0.6443^{***}$ (0.1205) | $0.6742^{***}$ (0.0600) | $-0.0006$ (0.0005) |
| **Δ Corp. prof.** | 0.01 | $0.6205^{***}$ (0.1198) | $0.6842^{***}$ (0.0594) | 0.0001 (0.0008) |
| **Δ GDP deflator** | 0.17 | $0.6479^{***}$ (0.1244) | $0.6824^{***}$ (0.0594) | $-0.0059$ (0.0086) |
| **NAI** | 0.77 | $0.7113^{***}$ (0.1326) | $0.6380^{***}$ (0.0667) | $-0.0426$ (0.0288) |
| **New orders** | 0.16 | $0.7685^{***}$ (0.2501) | $0.6684^{***}$ (0.0638) | $-0.0021$ (0.0032) |
| **Δ Cons. sent.** | 0.21 | $0.6092^{***}$ (0.1201) | $0.6911^{***}$ (0.0600) | 0.0034 (0.0044) |
| **Δ real cons.** | 0.10 | $0.5920^{***}$ (0.1318) | $0.6931^{***}$ (0.0617) | 0.0043 (0.008) |
| **Term spread** | 0.78 | $0.6701^{***}$ (0.1224) | $0.6823^{***}$ (0.0590) | $-0.0265$ (0.0177) |
| **Panel B** | | | | |
| **Δ real GDP: 2s** | 1.05 | $-0.0207$ (0.3892) | $0.6344^{***}$ (0.0654) | $0.3594^{*}$ (0.2072) |
| **Δ Ind.prod.: 2s** | 2.40 | $-0.3219$ (0.3737) | $0.5981^{***}$ (0.0664) | $0.5397^{***}$ (0.2029) |
| **Δ Unemp.: 2s** | 3.36 | $-0.5031$ (0.3728) | $0.5657^{***}$ (0.0685) | $0.6585^{***}$ (0.2073) |
| **Δ Housing: 2s** | 2.57 | $-0.1446$ (0.3017) | $0.5980^{***}$ (0.0658) | $0.4538^{***}$ (0.1647) |
| **Δ Corp. prof.: 2s** | 2.17 | $-0.2359$ (0.3595) | $0.6176^{***}$ (0.0639) | $0.4805^{***}$ (0.1903) |
| **Δ GDP deflator: 2s** | 0.03 | 0.9118 (1.0084) | $0.6823^{***}$ (0.0597) | $-0.1380$ (0.4781) |
| **NAI: 1s** | 0.57 | 0.1126 (0.4161) | $0.6432^{***}$ (0.0672) | 0.2862 (0.2239) |
| **New orders: 1s** | 0.31 | 0.3173 (0.3457) | $0.6607^{***}$ (0.0642) | 0.1707 (0.1815) |
| **Δ Cons. sent.: 1s (ur)** | 1.66 | $-0.2520$ (0.4146) | $0.6196^{***}$ (0.0654) | $0.4837^{**}$ (0.2199) |
| **Δ real cons.: 1s (ur)** | 0.02 | 0.5183 (0.5284) | $0.6801^{***}$ (0.0624) | 0.0541 (0.2667) |
| **Term spread: 1s (ur)** | 4.18 | $-0.5739$ (0.3539) | $0.5914^{***}$ (0.0626) | $0.6707^{***}$ (0.1877) |

**Notes:** We estimate an AR(1) model for $\log(\sqrt{RV_t})$ and two types of predictive regressions

$$\log\left(\sqrt{RV_t}\right) = c + \rho \log\left(\sqrt{RV_{t-1}}\right) + \theta X_{t-1} + \zeta_t \qquad \text{(Panel A)}$$

$$\log\left(\sqrt{RV_t}\right) = c + \rho \log\left(\sqrt{RV_{t-1}}\right) + \theta \log\left(\sqrt{N^{(t)}\hat{\tau}_t^X}\right) + \zeta_t \qquad \text{(Panel B)}$$

where the regression is either augmented by the first lag of a macro variable $X_t$ or by the quarterly aggregated long-term component $N^{(t)}\hat{\tau}_t^X$ from the respective GARCH-MIDAS-X model. We either include the long-term component from the feasible two-sided specification with the highest variance ratio, see Section 4.2 and Table 4 or Table A.2, or from the one-sided specification for variables which are not included in the SPF dataset. For leading variables we include an unrestricted (ur) weighting scheme in the one-sided specification, see Section 4.1.1 and Table 2.

Robust standard errors are presented in parentheses and $^{***}$,$^{**}$ ,$^{*}$ indicate significance at the 1%, 5%, and 10% level. $\Delta R^2$ the increase in the percentage $R^2$ for the predictive regressions relative to a baseline AR(1) model for $log(\sqrt{RV_t})$. The percentage $R^2$ value for the latter is 47.06. We consider the 1973Q1 - 2010Q4 sample.

Table A.9: One-sided GARCH-MIDAS-X specifications - subsample until 2007Q2

| Variable | $\mu$ | $\alpha$ | $\beta$ | $\gamma$ | $m$ | $\theta$ | $\omega_1$ | $\omega_2$ | LLF | BIC | VR(X) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Δ real GDP** | $0.0279^{***}$ | $0.0206^{***}$ | $0.9212^{***}$ | $0.0830^{***}$ | 0.1291 | $-0.0784^{***}$ | 1 | $4.9503^{***}$ | −11228.44 | 2.5862 | 8.28 |
| | (0.0088) | (0.0053) | (0.0176) | (0.0247) | (0.1680) | (0.0256) | | (1.3855) | | | |
| | $0.0279^{***}$ | $0.0205^{***}$ | $0.9212^{***}$ | $0.0830^{***}$ | 0.1333 | $-0.0804^{***}$ | 1.4419 | $6.1071^{*}$ | −11228.37 | 2.5872 | 8.71 |
| | (0.0088) | (0.0053) | (0.0177) | (0.0247) | (0.1686) | (0.0279) | (1.6310) | (3.4171) | [0.7090] | | |
| **Δ Ind. prod.** | $0.0279^{***}$ | $0.0197^{***}$ | $0.9204^{***}$ | $0.0841^{***}$ | 0.0275 | $-0.0440^{***}$ | 1 | $4.7537^{***}$ | −11227.73 | 2.5860 | 9.20 |
| | (0.0088) | (0.0054) | (0.0182) | (0.0249) | (0.1483) | (0.0145) | | (1.3649) | | | |
| | $0.0279^{***}$ | $0.0195^{***}$ | $0.9206^{***}$ | $0.0841^{***}$ | 0.0292 | $-0.0451^{***}$ | 1.6951 | $6.8203^{*}$ | −11227.51 | 2.5870 | 10.04 |
| | (0.0088) | (0.0054) | (0.0184) | (0.0250) | (0.1477) | (0.0146) | (1.4509) | (3.7626) | [0.5075] | | |
| **Δ Unemp.** | $0.0285^{***}$ | $0.0207^{***}$ | $0.9200^{***}$ | $0.0830^{***}$ | −0.0798 | $0.5949^{***}$ | 1 | $6.7929^{***}$ | −11229.13 | 2.5863 | 6.96 |
| | (0.0088) | (0.0053) | (0.0182) | (0.0250) | (0.1455) | (0.2146) | | (2.4410) | | | |
| | $0.0285^{***}$ | $0.0206^{***}$ | $0.9201^{***}$ | $0.0829^{***}$ | −0.0799 | $0.6067^{***}$ | 1.6474 | 9.3800 | −11229.04 | 2.5874 | 7.33 |
| | (0.0088) | (0.0053) | (0.0182) | (0.0249) | (0.1456) | (0.2272) | (1.4843) | (5.7780) | [0.6630] | | |
| **Δ Housing** | $0.0279^{***}$ | $0.0226^{***}$ | $0.9173^{***}$ | $0.0841^{***}$ | 0.0467 | $-0.0158^{***}$ | 1 | $1.7973^{***}$ | −11223.93 | 2.5851 | 13.80 |
| | (0.0088) | (0.0053) | (0.0183) | (0.0250) | (0.1612) | (0.0061) | | (0.3130) | | | |
| | $0.0280^{***}$ | $0.0204^{***}$ | $0.9192^{***}$ | $0.0848^{***}$ | 0.0531 | $-0.0181^{***}$ | $2.7513^{**}$ | $4.6860^{*}$ | −11218.68 | 2.5850 | 24.31 |
| | (0.0088) | (0.0052) | (0.0178) | (0.0244) | (0.1592) | (0.0060) | (1.3976) | (2.5419) | [0.0012] | | |
| **Δ Corp. prof.** | $0.0276^{***}$ | $0.0189^{***}$ | $0.9195^{***}$ | $0.0870^{***}$ | 0.1713 | $-0.0209^{***}$ | 1 | $2.7734^{**}$ | −11220.70 | 2.5844 | 19.80 |
| | (0.0088) | (0.0054) | (0.0174) | (0.0241) | (0.1596) | (0.0055) | | (1.1714) | | | |
| | $0.0276^{***}$ | $0.0189^{***}$ | $0.9196^{***}$ | $0.0869^{***}$ | 0.1723 | $-0.0210^{***}$ | $1.0682^{**}$ | $2.9064^{*}$ | −11220.69 | 2.5854 | 19.99 |
| | (0.0088) | (0.0055) | (0.0177) | (0.0243) | (0.1588) | (0.0058) | (0.5240) | (1.5435) | [0.8775] | | |
| **Δ GDP deflator** | $0.0286^{***}$ | $0.0218^{***}$ | $0.9226^{***}$ | $0.0802^{***}$ | −0.1971 | 0.0329 | 1 | $3.6621^{***}$ | −11233.92 | 2.5874 | 1.98 |
| | (0.0088) | (0.0052) | (0.0175) | (0.0245) | (0.1969) | (0.0265) | | (0.9866) | | | |
| | $0.0286^{***}$ | $0.0211^{***}$ | $0.9236^{***}$ | $0.0801^{***}$ | −0.2355 | $0.0417^{*}$ | $43.3837^{***}$ | $71.5576^{***}$ | −11232.39 | 2.5881 | 3.62 |
| | (0.0088) | (0.0052) | (0.0175) | (0.0245) | (0.1877) | (0.0216) | (10.0414) | (4.7563) | [0.0807] | | |
| **NAI** | $0.0275^{***}$ | $0.0191^{***}$ | $0.9201^{***}$ | $0.0853^{***}$ | −0.0630 | $-0.3262^{***}$ | 1 | $7.3653^{***}$ | −11223.99 | 2.5851 | 13.28 |
| | (0.0088) | (0.0055) | (0.0178) | (0.0247) | (0.1443) | (0.0905) | | (2.6667) | | | |
| | $0.0276^{***}$ | $0.0191^{***}$ | $0.9202^{***}$ | $0.0851^{***}$ | −0.0630 | $-0.3270^{***}$ | 1.6149 | $9.9014^{**}$ | −11223.90 | 2.5862 | 13.56 |
| | (0.0088) | (0.0054) | (0.0179) | (0.0247) | (0.1446) | (0.0908) | (1.2684) | (4.9752) | [0.6796] | | |
| **New orders** | $0.0270^{***}$ | $0.0171^{***}$ | $0.9197^{***}$ | $0.0884^{***}$ | $2.6249^{***}$ | $-0.0495^{***}$ | 1 | $4.5362^{***}$ | −11216.69 | 2.5835 | 22.31 |
| | (0.0088) | (0.0055) | (0.0177) | (0.0246) | (0.6065) | (0.0108) | | (1.7595) | | | |
| | $0.0270^{***}$ | $0.0171^{***}$ | $0.9197^{***}$ | $0.0883^{***}$ | $2.6143^{***}$ | $-0.0493^{***}$ | 1.0614 | $4.7447^{**}$ | −11216.69 | 2.5845 | 22.33 |
| | (0.0088) | (0.0055) | (0.0177) | (0.0247) | (0.5977) | (0.0106) | (0.7734) | (2.3070) | [0.9604] | | |
| **Δ Cons. sent.** | $0.0282^{***}$ | $0.0217^{***}$ | $0.9179^{***}$ | $0.0846^{***}$ | −0.0714 | $-0.1057^{***}$ | 1 | $1.7461^{***}$ | −11229.34 | 2.5864 | 6.93 |
| | (0.0088) | (0.0053) | (0.0186) | (0.0255) | (0.1456) | (0.0381) | | (0.2664) | | | |
| | $0.0286^{***}$ | $0.0215^{***}$ | $0.9197^{***}$ | $0.0828^{***}$ | −0.0712 | $-0.1291^{***}$ | $2.8365^{***}$ | $4.9146^{**}$ | −11222.52 | 2.5859 | 15.58 |
| | (0.0088) | (0.0053) | (0.0181) | (0.0247) | (0.1489) | (0.0360) | (0.7517) | (2.1287) | [0.0002] | | |
| **Δ real cons.** | $0.0277^{***}$ | $0.0213^{***}$ | $0.9202^{***}$ | $0.0843^{***}$ | 0.2219 | $-0.0916^{**}$ | 1 | $3.6243^{***}$ | −11231.29 | 2.5868 | 5.03 |
| | (0.0088) | (0.0052) | (0.0177) | (0.0252) | (0.2313) | (0.0460) | | (1.1946) | | | |
| | $0.0284^{***}$ | $0.0218^{***}$ | $0.9219^{***}$ | $0.0811^{***}$ | 0.2881 | $-0.1140^{**}$ | 3.1662 | 9.8547 | −11229.28 | 2.5874 | 8.97 |
| | (0.0088) | (0.0052) | (0.0177) | (0.0254) | (0.2273) | (0.0454) | (2.8122) | (6.7650) | [0.0450] | | |
| **Term spread** | $0.0290^{***}$ | $0.0215^{***}$ | $0.9144^{***}$ | $0.0839^{***}$ | $0.3454^{**}$ | $-0.2744^{***}$ | 1 | $1.7635^{***}$ | −11218.60 | 2.5839 | 19.17 |
| | (0.0088) | (0.0055) | (0.0205) | (0.0264) | (0.1507) | (0.0552) | | (0.5996) | | | |
| | $0.0286^{***}$ | $0.0205^{***}$ | $0.9142^{***}$ | $0.0850^{***}$ | $0.3011^{**}$ | $-0.2492^{***}$ | $3.8873^{*}$ | $6.1866^{*}$ | −11216.83 | 2.5845 | 20.94 |
| | (0.0088) | (0.0054) | (0.0209) | (0.0268) | (0.1417) | (0.0464) | (2.1953) | (3.1754) | [0.0599] | | |
| **RV** | $0.0285^{***}$ | $0.0228^{***}$ | $0.9023^{***}$ | $0.0957^{***}$ | $-0.4617^{***}$ | $0.0055^{***}$ | 1 | 2.8690 | −11218.93 | 2.5840 | 16.67 |
| | (0.0087) | (0.0052) | (0.0213) | (0.0282) | (0.1495) | (0.0019) | | (2.5327) | | | |
| | $0.0285^{***}$ | $0.0229^{***}$ | $0.9007^{***}$ | $0.0968^{***}$ | $-0.4705^{***}$ | $0.0056^{***}$ | $0.7622^{*}$ | 2.3559 | −11218.69 | 2.5850 | 17.10 |
| | (0.0087) | (0.0052) | (0.0213) | (0.0282) | (0.1425) | (0.0018) | (0.4033) | (1.8402) | [0.4924] | | |
| **GARCH(1,1)** | $0.0287^{***}$ | $0.0221^{***}$ | $0.9237^{***}$ | $0.0789^{***}$ | −0.0589 | - | - | - | −11235.09 | 2.5856 | - |
| | (0.0088) | (0.0052) | (0.0172) | (0.0241) | (0.1644) | | | | | | |

**Notes:** The table reports estimation results for the one-sided GARCH-MIDAS-X models including 3 MIDAS lag years of a quarterly macro variable $X$, i.e, the long-run component is specified as

$$\log(\tau_t) = m + \theta \cdot \sum_{k=1}^{K} \varphi_k(\omega_1, \omega_2) X_{t-k},$$

where $K = 12$. All estimations are based on daily return data from 1973Q1 to 2007Q2 and quarterly macroeconomic data from 1970Q1 on. Otherwise, see the notes of Table A.1.

Table A.10: One-sided GARCH-MIDAS-RV-X specifications - subsample until 2007Q2

| Variable | $m$ | $\theta^{RV}$ | $w_2^{RV}$ | $\theta^X$ | $w_1^X$ | $w_2^X$ | LLF | BIC | VR(X) |
|---|---|---|---|---|---|---|---|---|---|
| **Δ real GDP** | $-0.3139^{**}$ | $0.0055^{***}$ | 2.6642 | $-0.0608^{***}$ | 1 | $6.3969^{***}$ | −11211.91 | 2.5845 | 23.52 |
| | (0.1535) | (0.0019) | (2.2918) | (0.0207) | | (2.3516) | | | |
| | $-0.3137^{*}$ | $0.0055^{***}$ | 2.6647 | $-0.0609^{***}$ | 1.0262 | 6.4750 | −11211.91 | 2.5855 | 23.53 |
| | (0.1608) | (0.0020) | (2.3031) | (0.0235) | (2.0301) | (4.3228) | [0.9475] | | |
| **Δ Ind. prod.** | $-0.3725^{**}$ | $0.0052^{***}$ | 3.1892 | $-0.0357^{***}$ | 1 | $5.6799^{***}$ | −11210.28 | 2.5841 | 26.28 |
| | (0.1488) | (0.0019) | (3.2753) | (0.0108) | | (1.7047) | | | |
| | $-0.3703^{**}$ | $0.0052^{***}$ | 3.2496 | $-0.0365^{***}$ | 1.8906 | $8.6561^{**}$ | −11210.01 | 2.5851 | 26.95 |
| | (0.1501) | (0.0020) | (3.5074) | (0.0109) | (1.5384) | (4.1049) | [0.4592] | | |
| **Δ Unemp.** | $-0.4538^{***}$ | $0.0052^{***}$ | 3.1159 | $0.4637^{***}$ | 1 | $7.9774^{**}$ | −11212.94 | 2.5847 | 23.01 |
| | (0.1458) | (0.0020) | (3.3439) | (0.1691) | | (3.5296) | | | |
| | $-0.4534^{***}$ | $0.0052^{***}$ | 3.1236 | $0.4683^{***}$ | 1.4047 | $9.6628^{**}$ | −11212.91 | 2.5857 | 23.12 |
| | (0.1462) | (0.0020) | (3.3885) | (0.1812) | (1.4611) | (4.2697) | [0.8185] | | |
| **Δ Housing** | $-0.3372^{**}$ | $0.0046^{**}$ | 3.0866 | $-0.0098^{**}$ | 1 | $2.2684^{***}$ | −11211.56 | 2.5844 | 23.82 |
| | (0.1627) | (0.0021) | (3.9622) | (0.0042) | | (0.6237) | | | |
| | $-0.3190^{**}$ | $0.0044^{**}$ | 2.9963 | $-0.0108^{**}$ | 3.0497 | 6.3012 | −11208.84 | 2.5848 | 27.16 |
| | (0.1582) | (0.0021) | (4.2936) | (0.0048) | (2.3699) | (4.6103) | [0.0197] | | |
| **Δ Corp. prof.** | $-0.3022^{**}$ | $0.0067^{***}$ | $3.0202^{*}$ | $-0.0224^{***}$ | 1 | $2.4239^{***}$ | −11192.69 | 2.5800 | 43.26 |
| | (0.1195) | (0.0016) | (1.6400) | (0.0043) | | (0.4825) | | | |
| | $-0.3196^{***}$ | $0.0069^{***}$ | $3.1179^{**}$ | $-0.0224^{***}$ | $1.7154^{***}$ | $3.6168^{***}$ | −11191.07 | 2.5807 | 45.41 |
| | (0.1147) | (0.0015) | (1.5348) | (0.0041) | (0.5075) | (0.8618) | [0.0721] | | |
| **Δ GDP deflator** | $-0.6143^{***}$ | $0.0056^{***}$ | 2.9068 | $0.0350^{*}$ | 1 | $3.8383^{***}$ | −11216.66 | 2.5856 | 17.97 |
| | (0.1812) | (0.0020) | (2.6008) | (0.0200) | | (1.2025) | | | |
| | $-0.6265^{***}$ | $0.0056^{***}$ | 2.9483 | $0.0378^{**}$ | $116.2248^{***}$ | $213.1336^{***}$ | −11215.33 | 2.5863 | 18.60 |
| | (0.1807) | (0.0020) | (2.7746) | (0.0172) | (11.0846) | (1.7851) | [0.1024] | | |
| **NAI** | $-0.4254^{***}$ | $0.0049^{**}$ | 3.5068 | $-0.2471^{***}$ | 1 | $9.1103^{**}$ | −11208.41 | 2.5837 | 27.71 |
| | (0.1462) | (0.0019) | (4.2894) | (0.0693) | | (4.2918) | | | |
| | $-0.4252^{***}$ | $0.0049^{**}$ | 3.5102 | $-0.2474^{***}$ | 1.2616 | $10.2807^{**}$ | −11208.40 | 2.5847 | 27.76 |
| | (0.1463) | (0.0019) | (4.2932) | (0.0704) | (1.3772) | (4.2830) | [0.9067] | | |
| **New orders** | $1.8133^{***}$ | $0.0054^{***}$ | 3.1312 | $-0.0419^{***}$ | 1 | $5.0161^{**}$ | −11197.60 | 2.5812 | 37.50 |
| | (0.4939) | (0.0016) | (2.5365) | (0.0090) | | (2.0022) | | | |
| | $1.8323^{***}$ | $0.0054^{***}$ | 3.1306 | $-0.0422^{***}$ | 0.8649 | $4.5393^{**}$ | −11197.59 | 2.5822 | 37.52 |
| | (0.4841) | (0.0016) | (2.5255) | (0.0089) | (0.7714) | (2.0090) | [0.8642] | | |
| **Δ Cons. sent.** | $-0.4648^{***}$ | $0.0054^{***}$ | 2.5953 | $-0.0867^{***}$ | 1 | $2.2106^{***}$ | −11212.08 | 2.5845 | 24.41 |
| | (0.1423) | (0.0018) | (1.8713) | (0.0291) | | (0.4158) | | | |
| | $-0.4736^{***}$ | $0.0056^{***}$ | 2.3139 | $-0.1016^{***}$ | $3.0757^{***}$ | $6.7877^{***}$ | −11206.00 | 2.5841 | 29.92 |
| | (0.1476) | (0.0018) | (1.4462) | (0.0297) | (0.6866) | (2.4311) | [0.0005] | | |
| **Δ real cons.** | $-0.2996^{*}$ | $0.0053^{***}$ | 2.5858 | −0.0475 | 1 | $5.6873^{**}$ | −11216.93 | 2.5856 | 18.06 |
| | (0.1763) | (0.0019) | (2.0351) | (0.0317) | | (2.2586) | | | |
| | −0.2530 | $0.0052^{***}$ | 2.5707 | −0.0601 | 3.0595 | $12.9027^{*}$ | −11216.26 | 2.5865 | 18.85 |
| | (0.1767) | (0.0018) | (2.1233) | (0.0391) | (2.8506) | (7.6446) | [0.2454] | | |
| **Term spread** | −0.1144 | $0.0057^{***}$ | 3.0076 | $-0.2442^{***}$ | 1 | $2.3460^{***}$ | −11195.72 | 2.5807 | 38.34 |
| | (0.1450) | (0.0020) | (2.5423) | (0.0453) | | (0.8676) | | | |
| | −0.1548 | $0.0058^{***}$ | 2.8084 | $-0.2250^{***}$ | 4.8994 | 9.9784 | −11193.06 | 2.5812 | 40.37 |
| | (0.1349) | (0.0018) | (1.8745) | (0.0411) | (3.1349) | (7.2785) | [0.0211] | | |
| **RV** | $-0.4617^{***}$ | $0.0055^{***}$ | 2.8690 | - | - | - | −11218.93 | 2.5840 | 16.67 |
| | (0.1495) | (0.0019) | (2.5327) | | | | | | |

**Notes:** The table reports estimation results for the one-sided GARCH-MIDAS-RV-X models including 3 MIDAS lag years of quarterly realized volatility and a macro variable X. We include a restricted weighting scheme for the RV variable and both restricted and unrestricted weights for the macro variable, i.e, the long-run component is specified as

$$\log(\tau_t) = m + \theta^{RV} \cdot \sum_{k=1}^{K} \varphi_k(1, \omega_2^{RV}) RV_{t-k} \; + \; \theta^X \cdot \sum_{k=1}^{K} \varphi_k(\omega_1^X, \omega_2^X) X_{t-k},$$

with $K = 12$. All estimations are based on daily return data from 1973Q1 to 2007Q2 and quarterly macroeconomic data from 1970Q1 on. The numbers in brackets are $p$-values from a likelihood ratio test $2(L_{UR} - L_R)$, where $L_{UR}$ is the likelihood of the GARCH-MIDAS-X specification including unrestricted weights and $L_R$ is the likelihood of the respective specification including restricted weights. Otherwise, see the notes of Table A.1.

Table A.11: One-sided GARCH-MIDAS-(RV)-X specifications - including monthly macro data

| Variable | $m$ | $\theta^{RV}$ | $w_2^{RV}$ | $\theta^X$ | $w_1^X$ | $w_2^X$ | LLF | BIC | VR(X) |
|---|---|---|---|---|---|---|---|---|---|
| **Δ Ind. prod.** | 0.1034 | - | - | $-0.0642^{***}$ | 1 | $4.0276^{***}$ | −12780.84 | 2.6716 | 12.74 |
| | (0.1318) | | | (0.0135) | | (0.8366) | | | |
| | 0.1017 | - | - | $-0.0641^{***}$ | $1.3351^{**}$ | $5.1695^{***}$ | −12780.51 | 2.6725 | 13.34 |
| | (0.1323) | | | (0.0131) | (0.5561) | (1.6379) | [0.4179] | | |
| **RV + Δ Ind. prod.** | −0.1116 | $0.0072^{*}$ | $1.6830^{**}$ | $-0.0519^{***}$ | 1 | $4.9934^{***}$ | −12776.70 | 2.6726 | 17.37 |
| | (0.1432) | (0.0039) | (0.7674) | (0.0134) | | (1.4924) | | | |
| | −0.1086 | $0.0071^{*}$ | $1.6606^{**}$ | $-0.0521^{***}$ | $1.1122^{**}$ | $5.4174^{***}$ | −12776.67 | 2.6736 | 17.37 |
| | (0.1463) | (0.0041) | (0.7516) | (0.0138) | (0.5427) | (1.7527) | [0.8127] | | |
| **Δ Unemp.** | −0.1093 | - | - | $0.0110^{***}$ | 1 | $6.8834^{*}$ | −12779.93 | 2.6714 | 12.20 |
| | (0.1339) | | | (0.0027) | | (3.9504) | | | |
| | −0.1098 | - | - | $0.0111^{***}$ | 0.5118 | $3.9937^{***}$ | −12778.83 | 2.6721 | 11.80 |
| | (0.1316) | | | (0.0023) | (0.3261) | (1.0882) | [0.1373] | | |
| **RV + Δ Unemp.** | $-0.3007^{**}$ | $0.0084^{**}$ | $1.8560^{**}$ | $0.0073^{***}$ | 1 | $15.6081^{*}$ | −12774.88 | 2.6723 | 17.17 |
| | (0.1237) | (0.0034) | (0.8650) | (0.0020) | | (8.9620) | | | |
| | $-0.2915^{**}$ | $0.0076^{**}$ | $1.7947^{**}$ | $0.0084^{***}$ | 0.3671 | $5.3028^{**}$ | −12774.34 | 2.6731 | 17.09 |
| | (0.1262) | (0.0037) | (0.8251) | (0.0022) | (0.3834) | (2.4831) | [0.3000] | | |
| **Δ Housing** | 0.0427 | - | - | −0.0004 | 1 | 1.7196 | −12795.69 | 2.6747 | 0.31 |
| | (0.1787) | | | (0.0007) | | (1.1973) | | | |
| | 0.0968 | - | - | $-0.0009^{*}$ | $13.0877^{***}$ | $21.2448^{***}$ | −12792.49 | 2.6750 | 4.14 |
| | (0.1701) | | | (0.0006) | (4.3119) | (4.9438) | [0.0114] | | |
| **RV + Δ Housing** | −0.2149 | $0.0089^{**}$ | $1.8619^{**}$ | −0.0002 | 1 | 2.2841 | −12790.58 | 2.6755 | 6.68 |
| | (0.1453) | (0.0036) | (0.8480) | (0.0005) | | (1.6697) | | | |
| | −0.1559 | $0.0085^{**}$ | $1.8788^{**}$ | $-0.0007^{*}$ | $13.2505^{***}$ | $22.9374^{***}$ | −12787.76 | 2.6759 | 9.50 |
| | (0.1489) | (0.0036) | (0.8257) | (0.0004) | (3.7321) | (5.5934) | [0.0176] | | |
| **NAI** | −0.0351 | - | - | $-0.3796^{***}$ | 1 | $7.4250^{***}$ | −12778.86 | 2.6712 | 16.98 |
| | (0.1284) | | | (0.0693) | | (2.5243) | | | |
| | −0.0351 | - | - | $-0.3823^{***}$ | 0.7809 | $6.2046^{**}$ | −12778.78 | 2.6721 | 16.96 |
| | (0.1281) | | | (0.0707) | (0.5930) | (2.7065) | [0.6970] | | |
| **RV + NAI** | −0.1897 | 0.0059 | $1.6853^{**}$ | $-0.3022^{***}$ | 1 | 10.9656 | −12776.47 | 2.6726 | 19.53 |
| | (0.1393) | (0.0043) | (0.7996) | (0.0813) | | (7.0142) | | | |
| | −0.1905 | 0.0059 | $1.7228^{**}$ | $-0.3050^{***}$ | 0.5587 | $7.4063^{*}$ | −12776.30 | 2.6735 | 19.57 |
| | (0.1366) | (0.0042) | (0.8441) | (0.0801) | (0.7623) | (4.3574) | [0.5638] | | |
| **New orders** | $3.0083^{***}$ | - | - | $-0.0556^{***}$ | 1 | $3.8584^{***}$ | −12774.22 | 2.6702 | 19.10 |
| | (0.5606) | | | (0.0101) | | (1.3016) | | | |
| | $3.0148^{***}$ | - | - | $-0.0558^{***}$ | $0.9821^{**}$ | $3.7946^{**}$ | −12774.22 | 2.6712 | 19.10 |
| | (0.5701) | | | (0.0101) | (0.4979) | (1.4942) | [1.0000] | | |
| **RV + New orders** | $2.3471^{***}$ | $0.0078^{**}$ | $1.6271^{**}$ | $-0.0473^{***}$ | 1 | $4.8753^{**}$ | −12769.06 | 2.6710 | 23.96 |
| | (0.6044) | (0.0040) | (0.6348) | (0.0103) | | (2.3150) | | | |
| | $2.4130^{***}$ | $0.0080^{**}$ | $1.6815^{**}$ | $-0.0486^{***}$ | 0.7072 | $3.6609^{**}$ | −12768.88 | 2.6720 | 24.38 |
| | (0.5768) | (0.0039) | (0.6766) | (0.0099) | (0.5159) | (1.4962) | [0.5521] | | |
| **Term spread** | $0.4233^{***}$ | - | - | $-0.2769^{***}$ | 1 | $1.4503^{***}$ | −12779.29 | 2.6713 | 12.93 |
| | (0.1478) | | | (0.0555) | | (0.4300) | | | |
| | $0.3653^{***}$ | - | - | $-0.2446^{***}$ | 4.8830 | 6.5897 | −12776.91 | 2.6717 | 14.80 |
| | (0.1378) | | | (0.0451) | (5.2942) | (5.2859) | [0.0290] | | |
| **RV + Term spread** | 0.0927 | $0.0122^{***}$ | $1.9639^{*}$ | $-0.2755^{***}$ | 1 | $1.8675^{***}$ | −12766.91 | 2.6706 | 24.20 |
| | (0.1239) | (0.0034) | (1.0265) | (0.0485) | | (0.5257) | | | |
| | 0.0389 | $0.0124^{***}$ | $1.9383^{**}$ | $-0.2502^{***}$ | 5.1274 | 8.3131** | −12763.09 | 2.6708 | 27.33 |
| | (0.1133) | (0.0035) | (0.9208) | (0.0408) | (3.8610) | (4.2296) | [0.0057] | | |
| **RV** | $-0.2405^{*}$ | $0.0091^{**}$ | $1.8671^{**}$ | - | - | - | −12790.75 | 2.6737 | 6.44 |
| | (0.1378) | (0.0037) | (0.8359) | | | | | | |
| **GARCH(1,1)** | 0.0049 | - | - | - | - | - | −12796.04 | 2.6728 | - |
| | (0.1553) | | | | | | | | |

**Notes:** The table reports estimation results for the one-sided GARCH-MIDAS-X models, i.e, the long-run component is specified as

$$\log(\tau_t^X) = m + \theta^X \cdot \sum_{k=1}^{K} \varphi_k(\omega_1^X, \omega_2^X) X_{t-k},$$

and the one-sided GARCH-MIDAS-RV-X models with a restricted weighting scheme for RV, i.e, the long-run component is specified as

$$\log(\tau_t^X) = m + \theta^{RV} \cdot \sum_{k=1}^{K} \varphi_k(1, \omega_2^{RV}) RV_{t-k} \; + \; \theta^X \cdot \sum_{k=1}^{K} \varphi_k(\omega_1^X, \omega_2^X) X_{t-k},$$

where in both cases we include 3 MIDAS lag years of monthly data, i.e. K = 36. All model estimations are based on daily return data from January 1973 to December 2010 and monthly macroeconomic data from January 1973 on. Otherwise, see the notes of Table A.1.

# B Figures

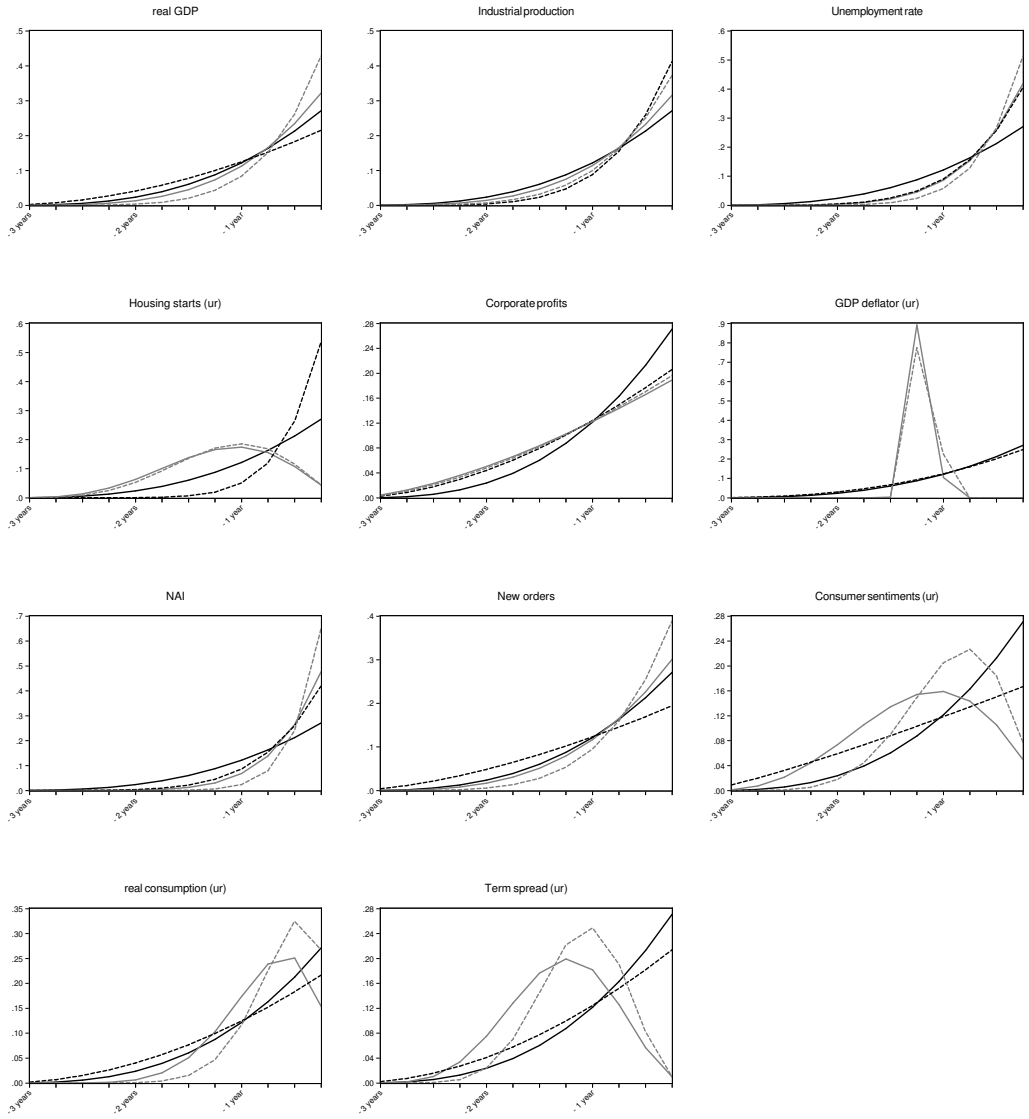


Figure B.1: The figures show the weighting schemes for the GARCH-MIDAS-RV (solid black line), GARCH-MIDAS-X (solid grey line), as well as for the GARCH-MIDAS-RV-X models (RV: dashed black line, X: dashed grey line). We include unrestricted weights for leading variables, see Table 3 and Section 4.1.2.

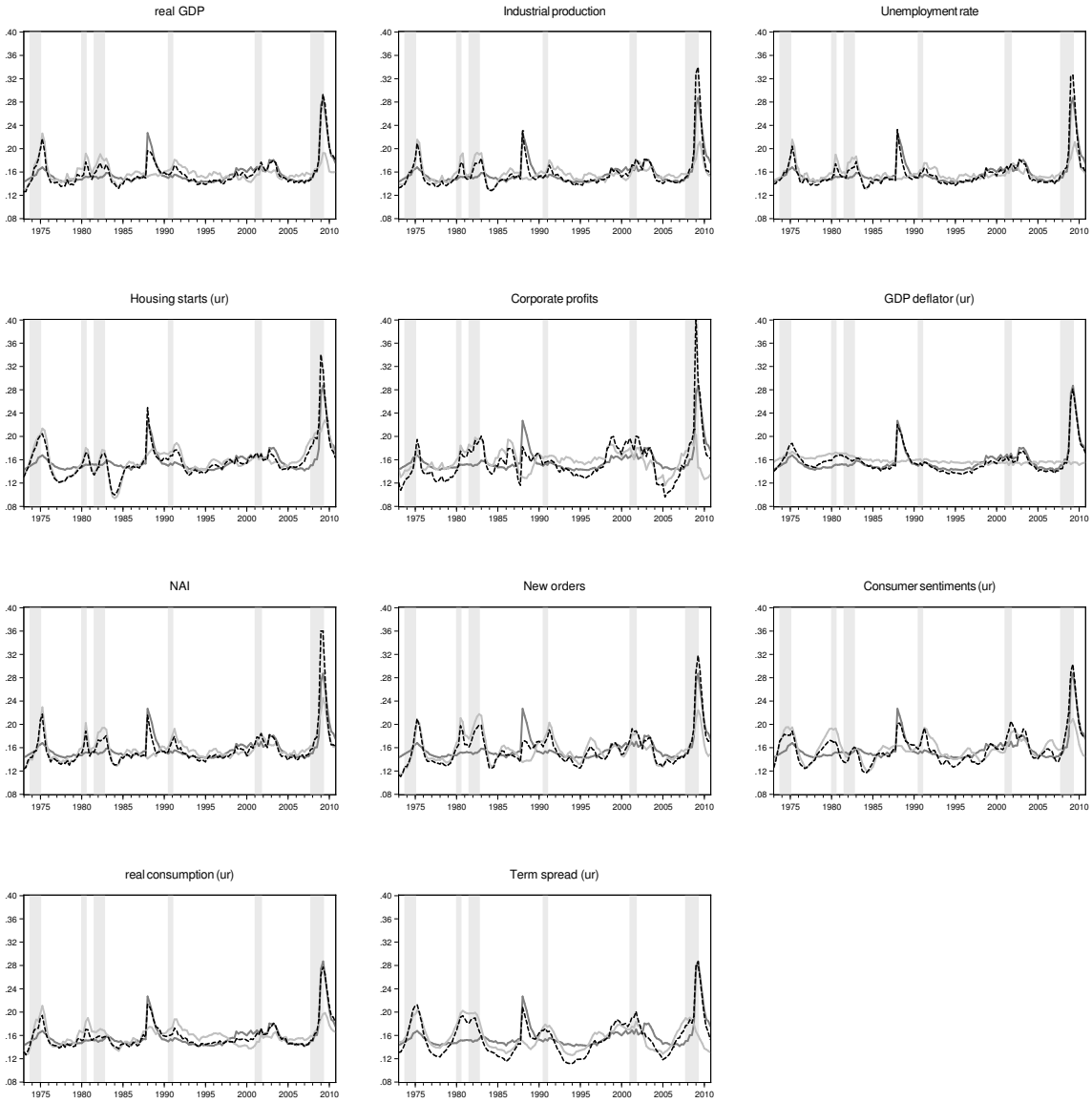


Figure B.2: The figures show the quarterly aggregated long-run volatility components $\sqrt{N^{(t)}\tau_t}$ for the GARCH-MIDAS-RV (solid grey line), GARCH-MIDAS-X (solid light grey line), as well as for the GARCH-MIDAS-RV-X models (dashed black line), see Table 3 and Section 4.1.2.

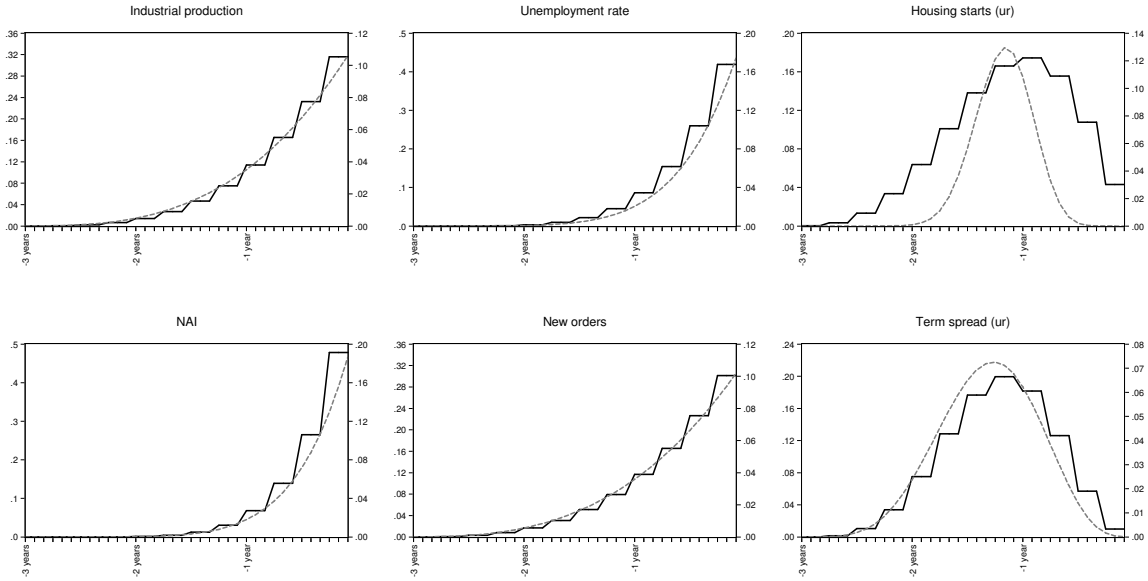


Figure B.3: The figures show the quarterly (solid black line, left scale) and monthly (dashed grey line, right scale) weighting schemes for all one-sided GARCH-MIDAS-X models for which monthly data is available, see Table A.11. Within each quarter, we keep the quarterly weights constant.