Online Appendix
On the Time-Varying Structure of the Arbitrage Pricing Theory using the Japanese Sector Indices

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Abstract: This note provides detailed explanations for the main document. In particular, we discuss the following topics: (1) descriptive statistics and unit root tests, (2) time-invariant estimation results in the main document, (3) time-varying estimates of $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$s, and (4) robustness check for the validity of the APT using the two Hansen-Jagannathan distances.

Keywords: Time-Varying Coefficient; Arbitrage Pricing Theory; Monetary Policy; Macroeconomic Risk; Generalized GRS Test

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A.1 Descriptive Statistics and Unit Root Tests

Table A.1 shows the results of descriptive statistics for each risk premium and risk factor.

(Table A.1 around here)

We can see that sample averages of all risk premiums for the Japanese sector indices are close to zero, and those sign conditions are negative. This is because our dataset includes the period of serious recessions in the 1990s–2010s called the "lost two decades in Japan." For the estimations, each variable that appeared in the moment conditions should be stationary. We apply the augmented Dickey–Fuller (ADF) test to confirm whether the stationarity condition is satisfied. We also employ Schwarz's (1978) Bayesian information criterion as the optimal lag order selection criteria in the estimation. Table A.1 also shows the results of the unit root test with descriptive statistics for the data. We can see that the ADF test rejects the null hypothesis that each variable contains a unit root at the 1% and 5% significance levels.

A.2 Time-Invariant Estimations

We apply Fama and MacBeth's (1973) two-step regression to investigate whether the APT is supported over the sample periods. Table A.2 provides us with the preliminary results.

(Table A.2 around here)

First, we discuss the estimates of $\boldsymbol{\alpha}$ (constants) and $\boldsymbol{\beta}_{MKT}$ (market portfolio risk factors), which are common parameters for CAPM and APT. The estimates of $\boldsymbol{\alpha}$ are close to zero for many sector indices. This implies that Equation (8) in the main document has high explanatory power for the Japanese sector indices. All estimates of $\boldsymbol{\beta}_{MKT}$ are statistically significant and satisfy the sign condition. However, whether the estimates are greater than one varies from sector to sector. This implies that each sector index is divided into aggressive and defensive assets relative to the market portfolio. This result is consistent with Thorbecke (2020), who examine the asymmetries among the sensitivity of risk factors on the Japanese sector indices during the COVID-19 global pandemic period.

Second, we confirm the estimates of other risk factors based on the APT as follows. We can see that there are asymmetries in the estimates of $\boldsymbol{\beta}_{WORLD}$ and $\boldsymbol{\beta}_{EMERGE}$ for each sector index. In particular, we can divide the sector indices into three groups that are significantly affected by: (i) only the WORLD index, (ii) only the EMERGE index, and (iii) both indices. The estimates of $\boldsymbol{\beta}_{CMD}$ are not statistically significant in almost all the sector indices. This implies that the changes in $\boldsymbol{\beta}_{CMD}$ are appropriately managed in many sectors. This result is partially consistent with Kaneko and Lee (1995), who examine whether economic state variables affect the Japanese stock returns. They find that the change in oil price does not significantly affect the Japanese stock returns. As for bond spreads, the estimates of $\boldsymbol{\beta}_{UTS}$ and $\boldsymbol{\beta}_{RP}$ are statistically significant mainly in the primary and tertiary industries. Finally, the estimates of $\boldsymbol{\beta}_{UYEN}$ and $\boldsymbol{\beta}_{UI}$ are not statistically significant in many sector indices. This suggests that the changes in these factors are appropriately managed in many sectors. This result is also consistent with Kaneko and Lee (1995), who find that the change in exchange rate is not important in explaining the stock returns.

Table A.2 also shows Kamstra and Shi's (2023) generalized Gibbons et al. (1989) test statistics. We apply the generalized GRS test to test whether the APT is valid on average for the sample period. We can not reject the null hypothesis that the APT is supported using the whole sample. Therefore, we conclude that the APT is supported over the sample periods.

A.3 Time-Varying Estimates of $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$s

We apply Fama and MacBeth's (1973) two-step regression with rolling windows to examine the time instability of the APT. Figures A.1 to A.10 show the time-varying estimates of $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$.

(Figures A.1 to A.9 around here)

In the rolling window regression, we set the 500 window width, corresponding to approximately two years. We can see that many estimates are not time stable over time and the nature of the estimates are quite different among the sectors. In the following, we summarize the estimation results for each parameter.

As described in the previous section, the estimates of $\boldsymbol{\alpha}$ (constants) and $\boldsymbol{\beta}_{MKT}$ are common parameters for the CAPM and APT. The time-varying estimates of $\boldsymbol{\alpha}$ are not statistically significant over time for almost all the sector indices. This indicates that Equation (8) has high explanatory power for the Japanese sector indices over the sample periods. In addition, the confidence intervals become smaller over time, implying that the explanatory power for the Japanese sector indices increases over time. This is consistent with the results of Noda (2016), who shows that the Japanese stock market has been efficient since around 2010. The time-varying estimates of $\boldsymbol{\beta}_{MKT}$ are significantly different from zero for all sample periods and satisfy the sign condition that the estimates are positive. However, whether the estimates are above one or not changes over time. This implies that their characteristics of being aggressive assets relative to the market portfolio (TOPIX in our case) are not stable. The time-varying estimates of $\boldsymbol{\beta}_{EMERGE}$ are more statistically significant in more time periods than the time-varying estimates of $\boldsymbol{\beta}_{WORLD}$. This suggests that the returns on Japanese sector indices are more affected by the returns on the EMERGE index than the returns on the WORLD index.

We find that the time-varying estimates of $\boldsymbol{\beta}_{CMD}$ have wide confidence intervals in some sector indices. The time-varying estimates of $\boldsymbol{\beta}_{CMD}$ are not significantly different from zero in most of the sample periods, which is consistent with the time-invariant estimates of $\boldsymbol{\beta}_{CMD}$. In addition, we find that the time-varying estimates and volatility of $\boldsymbol{\beta}_{CMD}$ are close to zero in all the sector indices during the COVID-19 global pandemic period. On the other hand, the volatilities of $\boldsymbol{\beta}_{CMD}$ increase after the beginning of the Russian invasion of Ukraine in 2022 (February 24, 2022).

The time-varying estimates of $\boldsymbol{\beta}_{UTS}$ are not significantly different from zero and are time stable in many periods. However, the estimates of $\boldsymbol{\beta}_{UTS}$ are significant in some financial sectors. In addition, we find that the volatility of $\boldsymbol{\beta}_{UTS}$ increases in many sectors during the COVID-19 global pandemic. For the estimates of $\boldsymbol{\beta}_{RP}$, there are asymmetries in the significance and the sign condition for each sector, some of which are positive over time, while others are negative over time. The time-varying estimates of $\boldsymbol{\beta}_{UYEN}$ are not statistically significant over time for many sector indices, but the volatilities are not stable over time. Finally, the time-varying estimates of $\boldsymbol{\beta}_{UI}$ are not stable in sign conditions, and they have wide confidence intervals. Moreover, their behavior is affected by the business cycles.

A.4 Robustness Check for the Validity of the APT

Some previous studies, such as Jagannathan and Wang (1996), Jagannathan et al. (1998), and Kubota and Takehara (2018), employ the Hansen and Jagannathan's (1997) distance (hereafter called the original HJ-distance) as well as the GRS test statistics to examine the validity of multi-factor models that include the APT. Note that the GRS statistic and the original HJ-distance are different statistics based on different concepts, regression and projection, respectively. More empirically, the null hypothesis tends to be over-rejected when the original HJ-distance is used than when the GRS statistics is used[1]. In this study, some time periods are detected where we cannot reject the null hypothesis using the GRS statistics. Therefore, we expect the null hypothesis to be rejected in almost all time periods when we employ the original HJ-distance.

Now, we introduce the original HJ-distance and Ren and Shimotsu's (2009) bias-corrected HJ-distance. We assume that there are N assets, and let $\boldsymbol{R}_t$ denote the t-th period gross returns of these assets. Here, $\boldsymbol{R}_t$ is a $1 \times N$ vector and satisfies the following equation:

$$\mathbb{E}[m_t \boldsymbol{R}_t] = \mathbf{1},$$

where m_t is a scalar and indicates a stochastic discount factor. Then we can define the original HJ-distance as follows:

$$HJ(\boldsymbol{\delta}) = \sqrt{\boldsymbol{w}_T(\boldsymbol{\delta})' \boldsymbol{G}_T^{-1} \boldsymbol{w}_T(\boldsymbol{\delta})}, \tag{A.1}$$

where

$$\begin{aligned} \boldsymbol{w}_T(\boldsymbol{\delta}) &= \frac{1}{T}\sum_{t=1}^{T} \boldsymbol{w}_t(\boldsymbol{\delta}) = \boldsymbol{D}_T \boldsymbol{\delta} - \mathbf{1}, \\ \boldsymbol{D}_T &= \frac{1}{T}\sum_{t=1}^{T} \boldsymbol{R}_t' \begin{pmatrix} \mathbf{1} & \boldsymbol{F}_t' \end{pmatrix}, \quad \boldsymbol{F}_t = \begin{pmatrix} f_{1,t} \\ f_{2,t} \\ \vdots \\ f_{m,t} \end{pmatrix}, \\ \boldsymbol{G}_T &= \frac{1}{T}\sum_{t=1}^{T} \boldsymbol{R}_t' \boldsymbol{R}_t. \end{aligned}$$

Note that $\boldsymbol{F}_t$ is factors used in the APT. Jagannathan and Wang (1996) show that $\boldsymbol{\delta}$ can be estimated as $\boldsymbol{\delta}_T$ in the following:

$$\boldsymbol{\delta}_T = (\boldsymbol{D}_T' T \boldsymbol{G}_T^{-1} \boldsymbol{D}_T)^{-1} \boldsymbol{D}_T' T \boldsymbol{G}_T^{-1} \mathbf{1},$$

where $\boldsymbol{\delta}_T$ is a $M \times 1$ vector. However, the weighting matrix $\boldsymbol{G}_T^{-1}$ is not as efficient as the optimal weighting matrix $\boldsymbol{\Omega}_T^{-1}$ used in the GMM estimation.

[1]The reason for this tendency may be due to the low test power of Hansen's (1982) J-test on which the original HJ-distance depends.

The optimal $\boldsymbol{\delta}_T$ is defined as:

$$\boldsymbol{\delta}_{OPT,T} = (\boldsymbol{D}'_T T \boldsymbol{\Omega}_T^{-1} \boldsymbol{D}_T)^{-1} \boldsymbol{D}'_T T \boldsymbol{\Omega}_T^{-1} \mathbf{1},$$

where

$$\boldsymbol{\Omega}_T = \frac{1}{T} \sum_{t=1}^{T} \boldsymbol{w}_t(\boldsymbol{\delta}_T) \boldsymbol{w}_t(\boldsymbol{\delta}_T)'.$$

Then we can obtain Hansen's (1982) J-statistic with $\boldsymbol{\delta}_{OPT,T}$ and $\boldsymbol{\Omega}_T^{-1}$ is defined as follows:

$$\boldsymbol{J}_T(\boldsymbol{\delta}_{OPT,T}) = T \boldsymbol{w}_T(\boldsymbol{\delta}_{OPT,T})' \boldsymbol{\Omega}_T^{-1} \boldsymbol{w}_T(\boldsymbol{\delta}_{OPT,T}) \sim \chi^2_{N-M}. \tag{A.2}$$

We examine whether the moment condition are holds using the J-statistics to verify the validity of the APT.

However, the original HJ-distance has an overrejection problem because the small sample properties of the GMM estimator is poor as shown in Ahn and Gadarowski (2004). Ren and Shimotsu (2009) propose the bias-corrected HJ-distance, which uses Stein's (1956) shrinkage method to mitigate the overrejection problem. In particular, they suggest replacing the optimal weighting matrix $\boldsymbol{\Omega}_T^{-1}$ with the shrinkage weighting matrix $\hat{\boldsymbol{G}}$ as follows:

$$\hat{\boldsymbol{G}} = \hat{\boldsymbol{\Sigma}} + \left(\frac{1}{T} \sum_{t=1}^{T} \boldsymbol{R}'_t \right) \left(\frac{1}{T} \sum_{t=1}^{T} \boldsymbol{R}_t \right)$$

where $\hat{\boldsymbol{\Sigma}}$ is the estimates of the shrinkage covariance matrix[2]. Then the bias-corrected HJ-distance is defined with $\hat{\boldsymbol{G}}$ in the following:

$$HJ(\hat{\boldsymbol{\delta}}_T) = \sqrt{\boldsymbol{w}_T(\hat{\boldsymbol{\delta}})' \hat{\boldsymbol{G}}_T^{-1} \boldsymbol{w}_T(\hat{\boldsymbol{\delta}})}, \tag{A.3}$$

where

$$\hat{\boldsymbol{\delta}}_T = (\boldsymbol{D}'_T T \hat{\boldsymbol{G}}_T^{-1} \boldsymbol{D}_T)^{-1} \boldsymbol{D}'_T T \hat{\boldsymbol{G}}_T^{-1} \mathbf{1}.$$

Then we replace $\boldsymbol{\delta}_{OPT,T}$ in Equation (A.2) with $\hat{\boldsymbol{G}}_T^{-1}$ and $\hat{\boldsymbol{\delta}}_T$, and derive the bias-corrected J-statistics as follows:

$$\boldsymbol{J}_T(\hat{\boldsymbol{\delta}}_T) = T \boldsymbol{w}_T(\hat{\boldsymbol{\delta}}_T)' \hat{\boldsymbol{G}}_T^{-1} \boldsymbol{w}_T(\hat{\boldsymbol{\delta}}_T). \tag{A.4}$$

Now, we calculate the J-statistic of the original and bias-corrected HJ-distances are 14.6539 and 14.2218, respectively, and we cannot reject the null hypothesis that the model is not misspecified. This means that the APT is valid entire the sample period. We next confirm the time-stability of the validity of the APT using the original and bias-corrected HJ-distances with rolling widonws.

(Figures A.10 and A.11 around here)

Figures A.10 and A.11 present the time-varying J-statistic of the original and bias-corrected HJ-distances, respectively. We can see that both statistics show a similar trend over time, but they differ in whether the null hypothesis is rejected. In particular, the test statistics for bias-corrected HJ-distances is rejected around September 20, 2005, when the Fed raised the federal funds rate. However, the point where the null hypothesis is rejected is not consistent with that of the GRS test (see the main document). Here, we have to keep in mind that the original and bias-corrected HJ-distances only focus on whether or not the orthogonal condition is satisfied. This means that the above two HJ-distances do not directly indicate whether the APT is valid or not.

[2] See Ren and Shimotsu (2009) for the detailed derivation process.

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Table A.1: Descriptive Statistics and Unit Root Tests

	Mean	SD	Min	Max	ADF	Lags
Risk Premiums						
FAF	−0.0007	0.0140	−0.1405	0.0848	−55.3076***	1
FOD	−0.0006	0.0114	−0.1216	0.0904	−57.0271***	1
MIN	−0.0007	0.0221	−0.1513	0.1392	−56.1616***	1
OIL	−0.0007	0.0186	−0.1468	0.1232	−56.8259***	1
CON	−0.0007	0.0146	−0.1204	0.1385	−54.3419***	1
MET	−0.0007	0.0152	−0.1381	0.1316	−55.7138***	1
GLC	−0.0007	0.0170	−0.1406	0.1279	−54.0907***	1
TEX	−0.0007	0.0144	−0.1200	0.1271	−55.2183***	1
PUL	−0.0008	0.0167	−0.1404	0.1101	−54.9889***	1
CHE	−0.0006	0.0137	−0.1119	0.1215	−55.4462***	1
PHA	−0.0006	0.0130	−0.1257	0.0930	−56.5371***	1
RUB	−0.0006	0.0190	−0.1455	0.1432	−48.7205***	2
TEQ	−0.0006	0.0171	−0.1210	0.1461	−55.6086***	1
IRS	−0.0007	0.0203	−0.1430	0.1828	−54.1389***	1
NFM	−0.0008	0.0192	−0.1418	0.1533	−53.6653***	1
MAC	−0.0006	0.0163	−0.1329	0.1453	−53.8973***	1
ELA	−0.0006	0.0167	−0.1284	0.1248	−53.7089***	1
PRE	−0.0005	0.0165	−0.1412	0.1256	−56.0035***	1
OTH	−0.0006	0.0156	−0.1192	0.1083	−54.4958***	1
INF	−0.0006	0.0168	−0.1199	0.1093	−55.6126***	1
SER	−0.0007	0.0143	−0.1158	0.1077	−51.7721***	1
ELP	−0.0008	0.0135	−0.1626	0.0873	−54.8107***	1
LTP	−0.0007	0.0125	−0.1009	0.0962	−56.0991***	1
MTP	−0.0005	0.0227	−0.1523	0.1470	−54.6567***	1
ATP	−0.0010	0.0174	−0.1487	0.1765	−56.0794***	1
WHS	−0.0007	0.0153	−0.1421	0.1025	−55.5643***	1
WHO	−0.0005	0.0176	−0.1504	0.1390	−52.7696***	1
RET	−0.0007	0.0140	−0.1355	0.0996	−54.2642***	1
BAK	−0.0009	0.0187	−0.1396	0.1356	−52.8330***	1
SEC	−0.0008	0.0228	−0.1558	0.1475	−53.1276***	1
INS	−0.0006	0.0193	−0.1705	0.1277	−47.3008***	2
OFB	−0.0008	0.0195	−0.1494	0.1309	−53.7033***	1
RES	−0.0007	0.0205	−0.1426	0.1571	−56.3406***	1
Risk Factors						
MKT	−0.0007	0.0134	−0.1061	0.1224	−53.8854***	1
WORLD	0.0002	0.0106	−0.1044	0.1163	−37.6164***	4
EMERGE	0.0001	0.0124	−0.0999	0.1295	−50.4589***	1
CMD	0.0000	0.0030	−0.0403	0.0360	−52.6411***	1
UTS	0.0082	0.0057	−0.0028	0.0222	−3.5218**	2
RP	−0.0089	0.0072	−0.0472	0.0125	−5.5670***	12
UYEN	−0.0001	0.0050	−0.2230	0.0351	−56.4280***	2
UI	0.0000	0.0006	−0.0157	0.0155	−38.3270***	7
VIX	−0.0001	0.0595	−0.3272	0.5523	−44.5083***	3

Notes:

(1) "ADF" and "Lags" denote the ADF test statistics and the lag order selected by the Schwarz's (1978) Bayesian information criterion, respectively.

(2) In computing the ADF test, a model with time trend and constant is assumed.

(3) "***" denotes statistically significant at the 1% level.

Table A.2: Time-invariant Estimates of $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$

	α	β_{MKT}	β_{WORLD}	β_{EMERGE}	β_{CMD}	β_{UTS}	β_{RP}	β_{UYEN}	β_{UI}	β_{VIX}	$\bar{R}^2$
FAF	0.0000	0.6712	0.0415	−0.0791	0.1127	0.2067	0.2205	−0.0498	−0.1115	−0.0135	0.4231
	[0.0002]	[0.0134]	[0.0170]	[0.0161]	[0.0447]	[0.0505]	[0.0396]	[0.0272]	[0.2331]	[0.0028]	
FOD	0.0001	0.6496	0.0371	−0.0813	0.0192	0.1548	0.1683	−0.0548	−0.0245	−0.0094	0.5679
	[0.0002]	[0.0095]	[0.0120]	[0.0114]	[0.0317]	[0.0361]	[0.0282]	[0.0192]	[0.1641]	[0.0019]	
MIN	0.0000	0.8161	−0.0384	0.1844	−0.1899	−0.0112	0.0100	−0.0387	0.2131	−0.0099	0.3193
	[0.0004]	[0.0231]	[0.0292]	[0.0277]	[0.0769]	[0.0870]	[0.0682]	[0.0467]	[0.4002]	[0.0047]	
OIL	−0.0002	0.8277	−0.0081	0.0469	−0.1239	0.1198	0.1055	0.0021	0.0224	−0.0142	0.4030
	[0.0003]	[0.0182]	[0.0230]	[0.0218]	[0.0606]	[0.0685]	[0.0538]	[0.0369]	[0.3158]	[0.0037]	
CON	0.0002	0.9066	0.0023	−0.0012	−0.0094	−0.0007	0.0303	−0.0507	−0.0592	0.0026	0.6831
	[0.0002]	[0.0104]	[0.0130]	[0.0125]	[0.0348]	[0.0403]	[0.0312]	[0.0206]	[0.1750]	[0.0021]	
MET	−0.0001	0.8916	0.0250	0.0056	−0.0251	0.0175	0.0226	−0.0052	−0.0329	−0.0123	0.6739
	[0.0002]	[0.0110]	[0.0139]	[0.0132]	[0.0366]	[0.0415]	[0.0325]	[0.0222]	[0.1901]	[0.0023]	
GLC	−0.0002	0.9913	−0.0078	0.0789	0.0406	−0.0343	−0.0540	−0.0062	−0.0230	−0.0149	0.7147
	[0.0002]	[0.0114]	[0.0144]	[0.0137]	[0.0382]	[0.0436]	[0.0341]	[0.0229]	[0.1960]	[0.0023]	
TEX	−0.0001	0.8632	0.0390	−0.0083	0.0203	0.0185	0.0222	−0.0350	−0.0297	−0.0084	0.6879
	[0.0002]	[0.0102]	[0.0128]	[0.0122]	[0.0340]	[0.0387]	[0.0303]	[0.0204]	[0.1747]	[0.0021]	
PUL	−0.0002	0.7996	0.0548	−0.0668	0.0477	0.0628	0.0721	−0.0534	−0.0920	−0.0016	0.3989
	[0.0003]	[0.0164]	[0.0206]	[0.0196]	[0.0545]	[0.0620]	[0.0485]	[0.0329]	[0.2818]	[0.0033]	
CHE	0.0001	0.9023	0.0189	0.0045	0.0565	0.0340	0.0375	−0.0249	0.0632	−0.0112	0.8364
	[0.0001]	[0.0070]	[0.0089]	[0.0084]	[0.0235]	[0.0267]	[0.0209]	[0.0141]	[0.1207]	[0.0014]	
PHA	0.0000	0.6974	0.0452	−0.1099	−0.0391	0.2447	0.2356	0.0031	0.0462	−0.0162	0.5154
	[0.0002]	[0.0114]	[0.0144]	[0.0137]	[0.0382]	[0.0436]	[0.0340]	[0.0230]	[0.1961]	[0.0023]	
RUB	0.0001	0.9609	0.0487	−0.0742	0.1177	−0.0502	−0.0375	−0.0217	−0.1327	−0.0068	0.4551
	[0.0003]	[0.0178]	[0.0224]	[0.0213]	[0.0591]	[0.0670]	[0.0525]	[0.0358]	[0.3068]	[0.0036]	
TEQ	−0.0001	1.1081	0.0416	−0.0179	0.0295	−0.0892	−0.1115	0.0114	0.2055	0.0077	0.7306
	[0.0002]	[0.0113]	[0.0141]	[0.0135]	[0.0377]	[0.0435]	[0.0338]	[0.0223]	[0.1902]	[0.0023]	
IRS	−0.0003	1.1128	−0.0186	0.1056	0.0703	−0.0293	−0.0665	−0.0862	0.6327	0.0012	0.5902
	[0.0003]	[0.0164]	[0.0206]	[0.0197]	[0.0549]	[0.0629]	[0.0490]	[0.0328]	[0.2796]	[0.0034]	
NFM	−0.0003	1.1058	−0.0490	0.1589	0.0484	−0.1247	−0.1422	−0.0794	0.2382	−0.0062	0.7016
	[0.0002]	[0.0132]	[0.0167]	[0.0158]	[0.0441]	[0.0503]	[0.0393]	[0.0266]	[0.2271]	[0.0027]	
MAC	0.0000	1.0388	−0.0153	0.0965	0.0262	−0.1181	−0.1176	−0.0158	0.0049	−0.0077	0.8333
	[0.0002]	[0.0084]	[0.0106]	[0.0101]	[0.0280]	[0.0321]	[0.0250]	[0.0168]	[0.1433]	[0.0017]	
ELA	0.0001	1.0722	−0.0262	0.1132	0.0013	−0.1473	−0.1285	0.0154	0.0412	−0.0063	0.8383
	[0.0002]	[0.0085]	[0.0106]	[0.0102]	[0.0285]	[0.0331]	[0.0257]	[0.0168]	[0.1426]	[0.0017]	

Table A.2: Time-invariant Estimates of $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ (continued)

	α	β_{MKT}	β_{WORLD}	β_{EMERGE}	β_{CMD}	β_{UTS}	β_{RP}	β_{UYEN}	β_{UI}	β_{VIX}	$\bar{R}^2$
PRE	0.0002	0.9792	−0.0154	0.0609	0.0318	−0.0489	−0.0411	0.0139	0.4358	−0.0102	0.7062
	[0.0002]	[0.0113]	[0.0142]	[0.0135]	[0.0376]	[0.0428]	[0.0335]	[0.0227]	[0.1940]	[0.0023]	
OTH	0.0003	0.8582	−0.0402	0.0591	0.0285	−0.0816	−0.0362	−0.0038	−0.3513	−0.0076	0.5934
	[0.0002]	[0.0126]	[0.0158]	[0.0151]	[0.0420]	[0.0480]	[0.0375]	[0.0252]	[0.2150]	[0.0026]	
INF	0.0001	0.9897	−0.0308	−0.0360	0.0080	0.1774	0.1646	0.0368	−0.1893	0.0024	0.5727
	[0.0003]	[0.0139]	[0.0175]	[0.0167]	[0.0465]	[0.0534]	[0.0416]	[0.0277]	[0.2366]	[0.0028]	
SER	0.0000	0.8647	−0.0114	−0.0101	−0.0623	0.1448	0.1470	−0.0086	0.1848	−0.0098	0.6816
	[0.0002]	[0.0102]	[0.0126]	[0.0122]	[0.0341]	[0.0400]	[0.0308]	[0.0199]	[0.1685]	[0.0021]	
ELP	−0.0002	0.5893	0.0664	−0.1950	0.0460	0.3275	0.3285	−0.0282	−0.0498	−0.0094	0.2972
	[0.0003]	[0.0143]	[0.0179]	[0.0171]	[0.0477]	[0.0546]	[0.0426]	[0.0285]	[0.2433]	[0.0029]	
LTP	−0.0001	0.7491	0.0503	−0.1670	−0.0044	0.2195	0.2159	−0.0482	0.1136	−0.0032	0.5548
	[0.0002]	[0.0105]	[0.0133]	[0.0126]	[0.0351]	[0.0399]	[0.0313]	[0.0212]	[0.1814]	[0.0022]	
MTP	0.0002	1.0345	−0.0073	0.1073	0.0427	−0.0353	−0.0283	−0.0333	0.0220	−0.0062	0.4261
	[0.0004]	[0.0217]	[0.0273]	[0.0260]	[0.0726]	[0.0833]	[0.0649]	[0.0433]	[0.3695]	[0.0044]	
ATP	−0.0003	0.7222	0.0458	−0.0818	0.0166	0.0076	0.0313	−0.0004	0.6880	−0.0004	0.2884
	[0.0003]	[0.0186]	[0.0235]	[0.0222]	[0.0618]	[0.0699]	[0.0548]	[0.0375]	[0.3213]	[0.0038]	
WHS	0.0001	0.8771	0.0360	−0.0605	−0.0600	0.1195	0.1259	−0.0447	−0.0864	−0.0064	0.5850
	[0.0002]	[0.0124]	[0.0157]	[0.0149]	[0.0415]	[0.0473]	[0.0370]	[0.0250]	[0.2135]	[0.0025]	
WHO	0.0001	1.0744	−0.0564	0.0979	0.0106	−0.0738	−0.0786	0.0212	−0.4208	0.0048	0.7054
	[0.0002]	[0.0120]	[0.0150]	[0.0144]	[0.0402]	[0.0466]	[0.0361]	[0.0237]	[0.2015]	[0.0024]	
RET	0.0000	0.8629	0.0178	−0.0921	−0.0075	0.1393	0.1421	−0.0328	−0.0154	−0.0017	0.6211
	[0.0002]	[0.0109]	[0.0137]	[0.0131]	[0.0365]	[0.0419]	[0.0326]	[0.0218]	[0.1857]	[0.0022]	
BAK	−0.0002	1.2173	0.0414	−0.0844	−0.0426	−0.1473	−0.1562	0.0365	0.1459	0.0248	0.6643
	[0.0003]	[0.0136]	[0.0170]	[0.0163]	[0.0458]	[0.0532]	[0.0412]	[0.0269]	[0.2284]	[0.0028]	
SEC	−0.0004	1.4527	−0.0442	0.0386	−0.0648	−0.2219	−0.2717	0.0323	0.1714	0.0270	0.6789
	[0.0003]	[0.0163]	[0.0205]	[0.0195]	[0.0545]	[0.0621]	[0.0485]	[0.0327]	[0.2796]	[0.0033]	
INS	0.0001	1.1190	0.0534	−0.0338	−0.0385	−0.2042	−0.1872	−0.0083	−0.0758	0.0169	0.5629
	[0.0003]	[0.0162]	[0.0204]	[0.0194]	[0.0539]	[0.0613]	[0.0480]	[0.0326]	[0.2788]	[0.0033]	
OFB	0.0001	1.1632	0.0094	0.0030	0.0675	−0.0795	−0.0647	−0.0332	−0.2315	0.0089	0.6206
	[0.0003]	[0.0152]	[0.0191]	[0.0182]	[0.0508]	[0.0581]	[0.0453]	[0.0304]	[0.2592]	[0.0031]	
RES	−0.0003	1.1946	0.0299	−0.0331	0.0358	0.0577	0.0036	−0.0269	0.1294	0.0060	0.5852
	[0.0003]	[0.0167]	[0.0209]	[0.0200]	[0.0558]	[0.0642]	[0.0500]	[0.0332]	[0.2834]	[0.0034]	
GRS	0.5617										

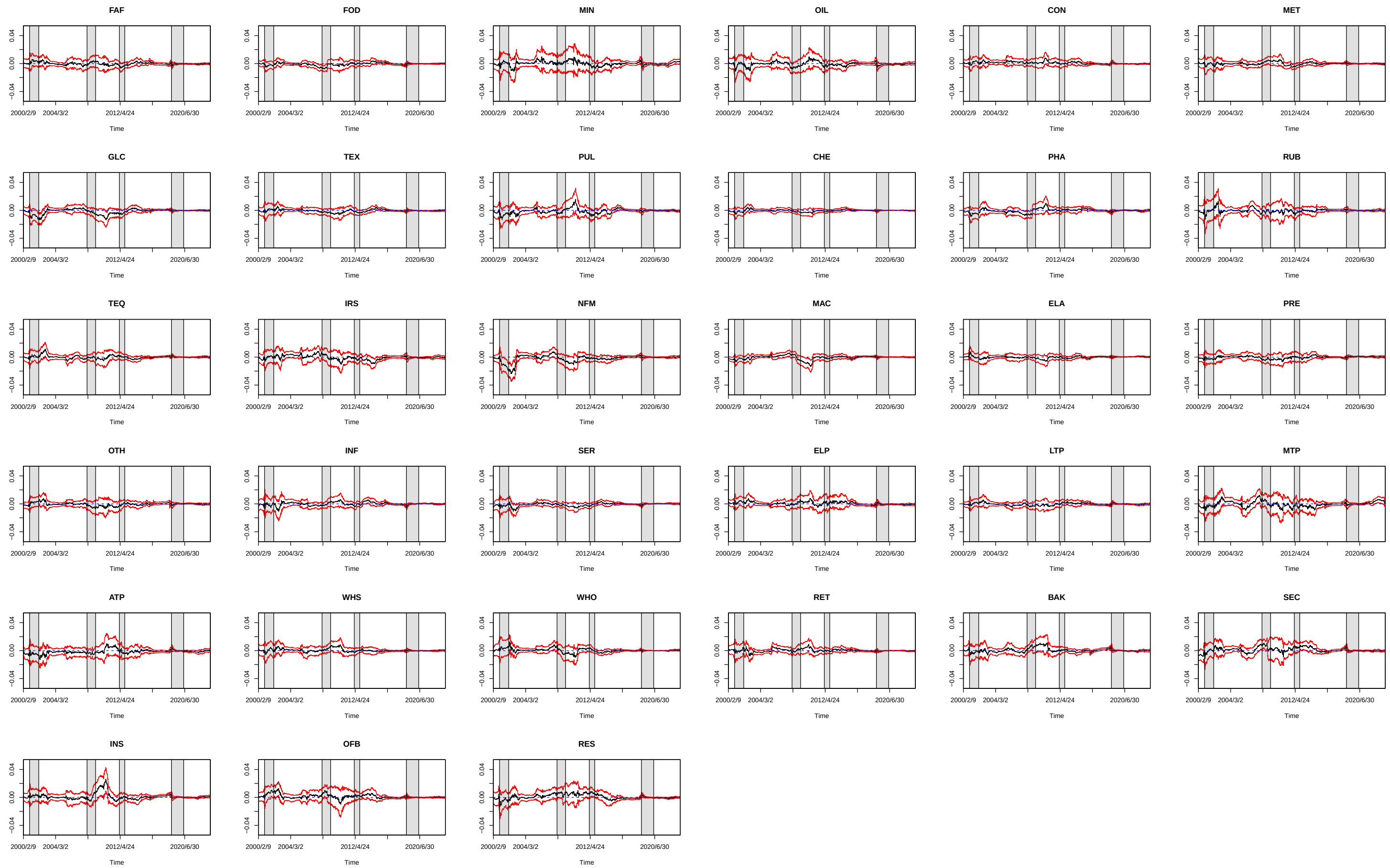
Notes:

(1) "$\bar{R}^2$" and "GRS" denote the adjusted R^2 and the generalized GRS statistics, respectively.

(2) The robust standard errors for the GLS estimation are shown in brackets.

(3) R version 4.3.1 was used to compute the estimates.

Figure A.1: Time-Varying Estimates of $\hat{\boldsymbol{\alpha}}$

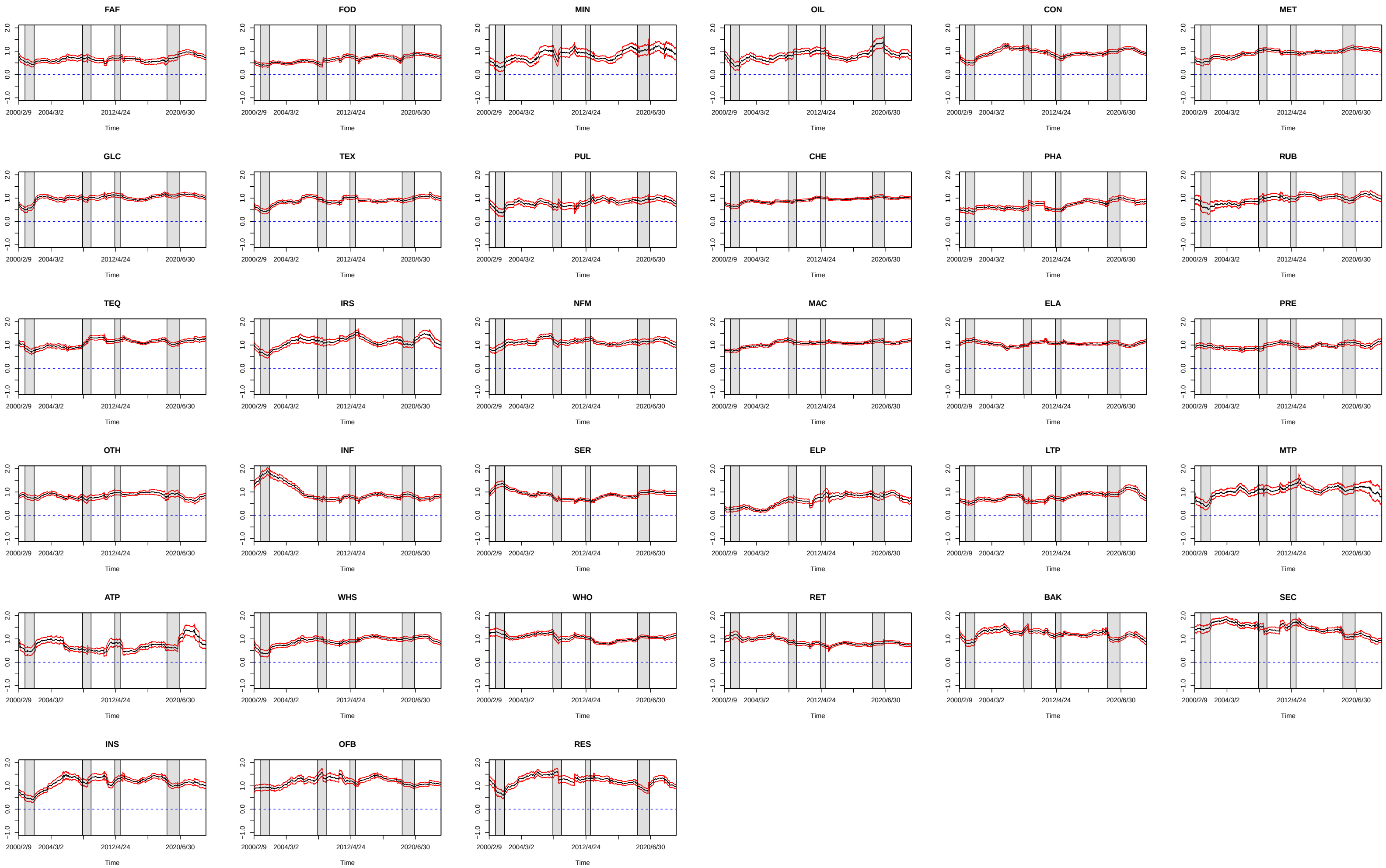


Notes:

(1) The dashed red lines represent the 95% confidence intervals of the estimates.

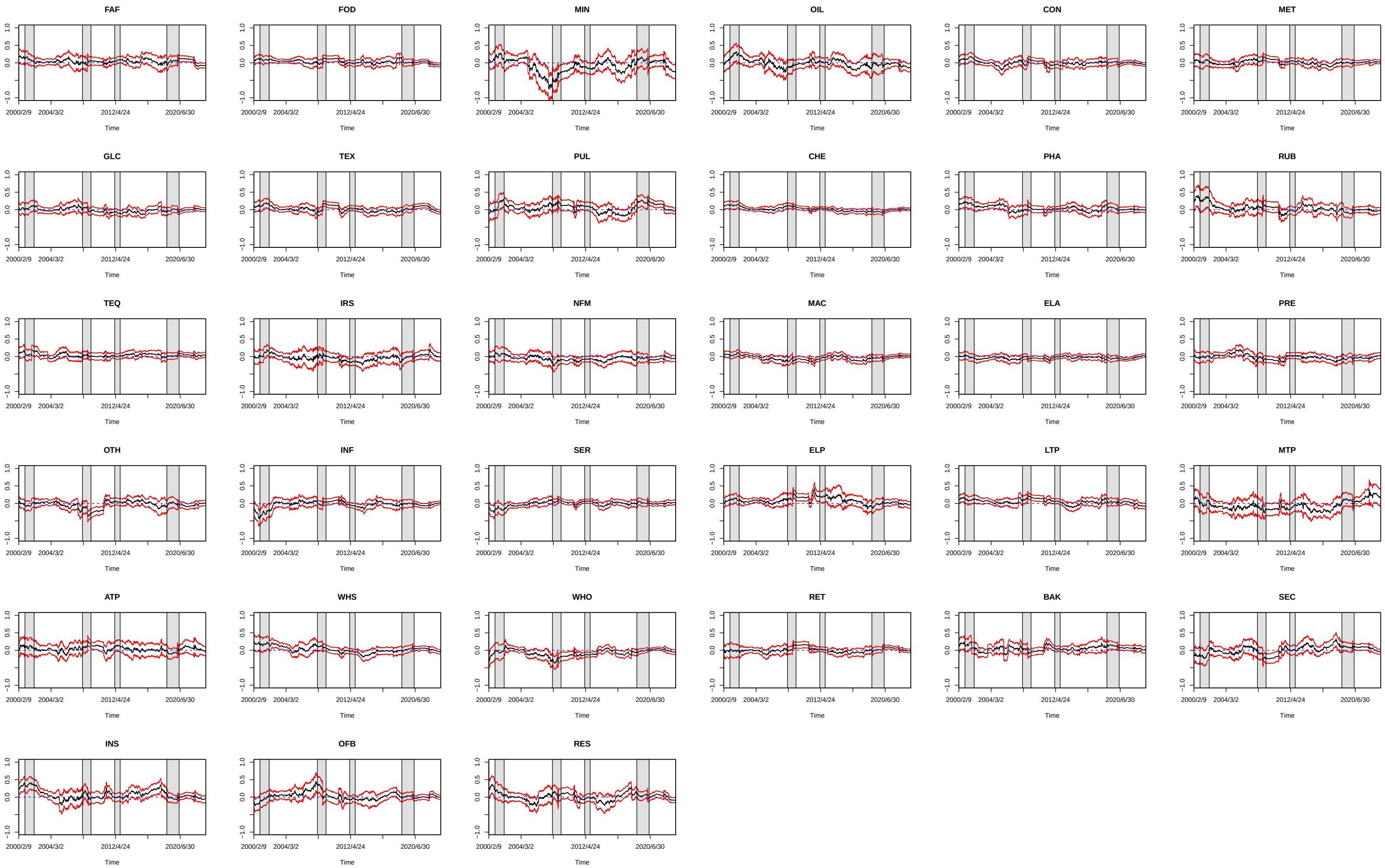
(2) The shade areas are recessions as defined by the Cabinet Office Japan "Indexes of Business Conditions."

Figure A.2: Time-Varying Estimates of $\hat{\boldsymbol{\beta}}_{MKT}$



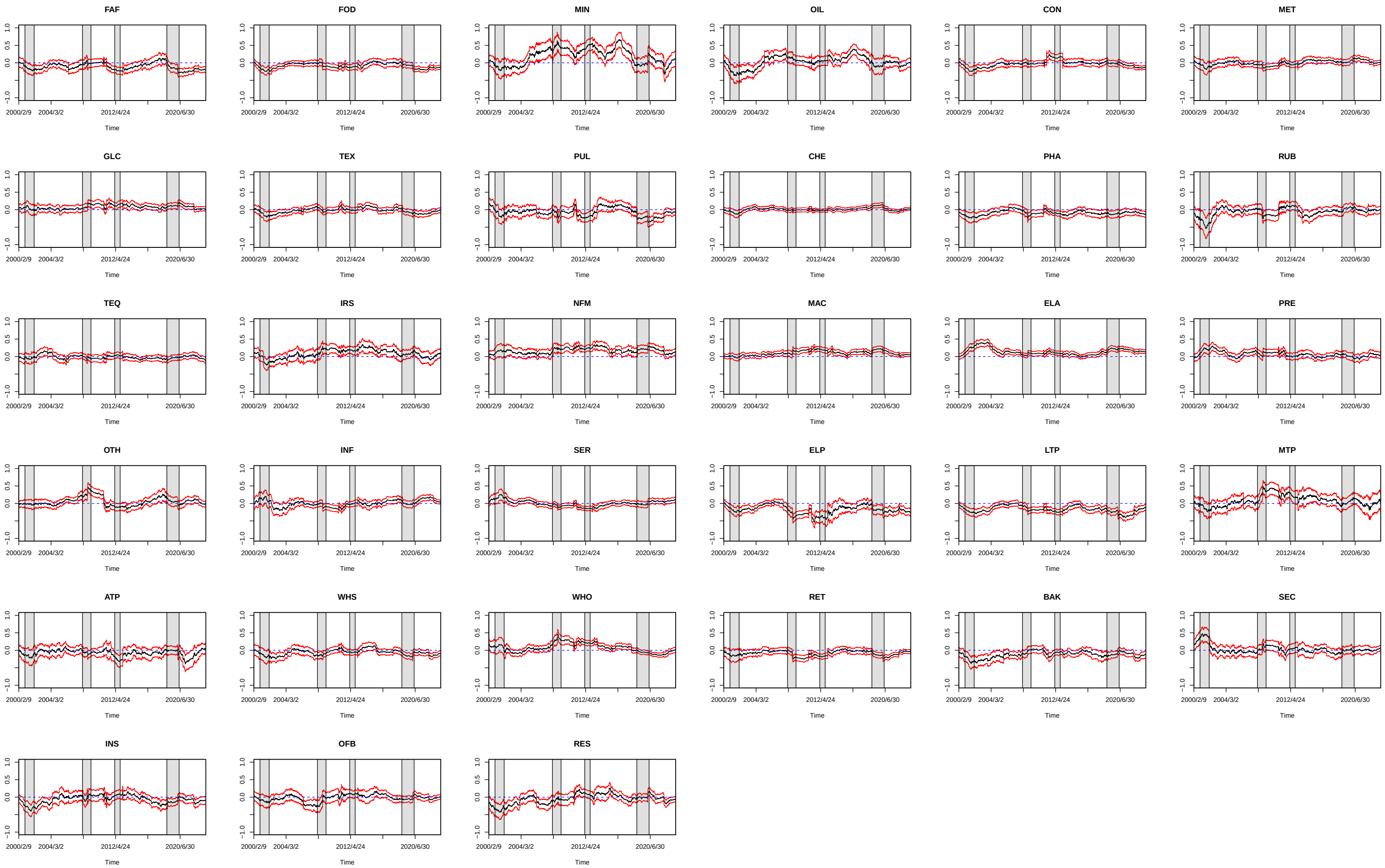
Note: As for Figure A.1.

Figure A.3: Time-Varying Estimates of $\hat{\boldsymbol{\beta}}_{WORLD}$



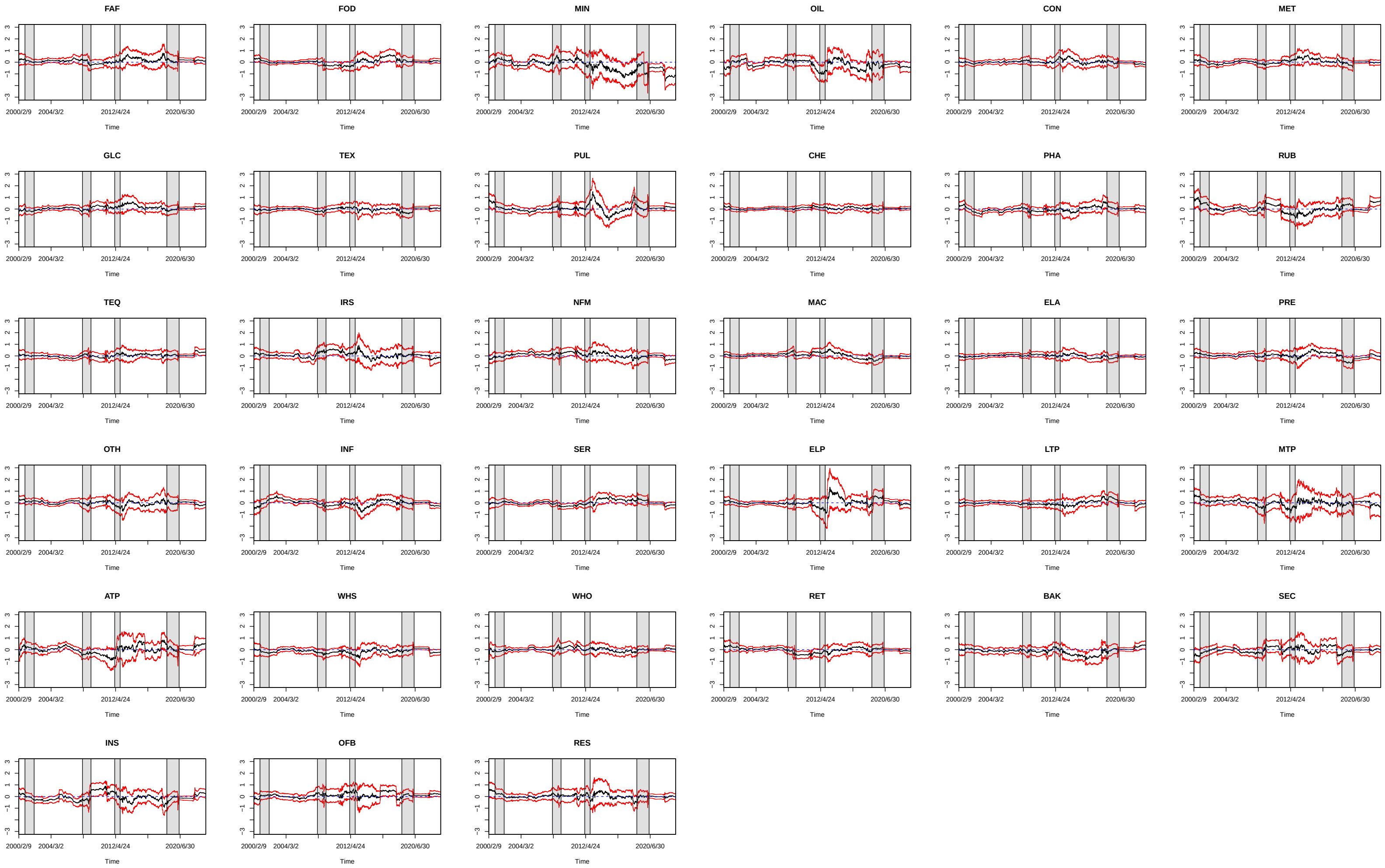
Note: As for Figure A.1.

Figure A.4: Time-Varying Estimates of $\hat{\boldsymbol{\beta}}_{EMERGE}$



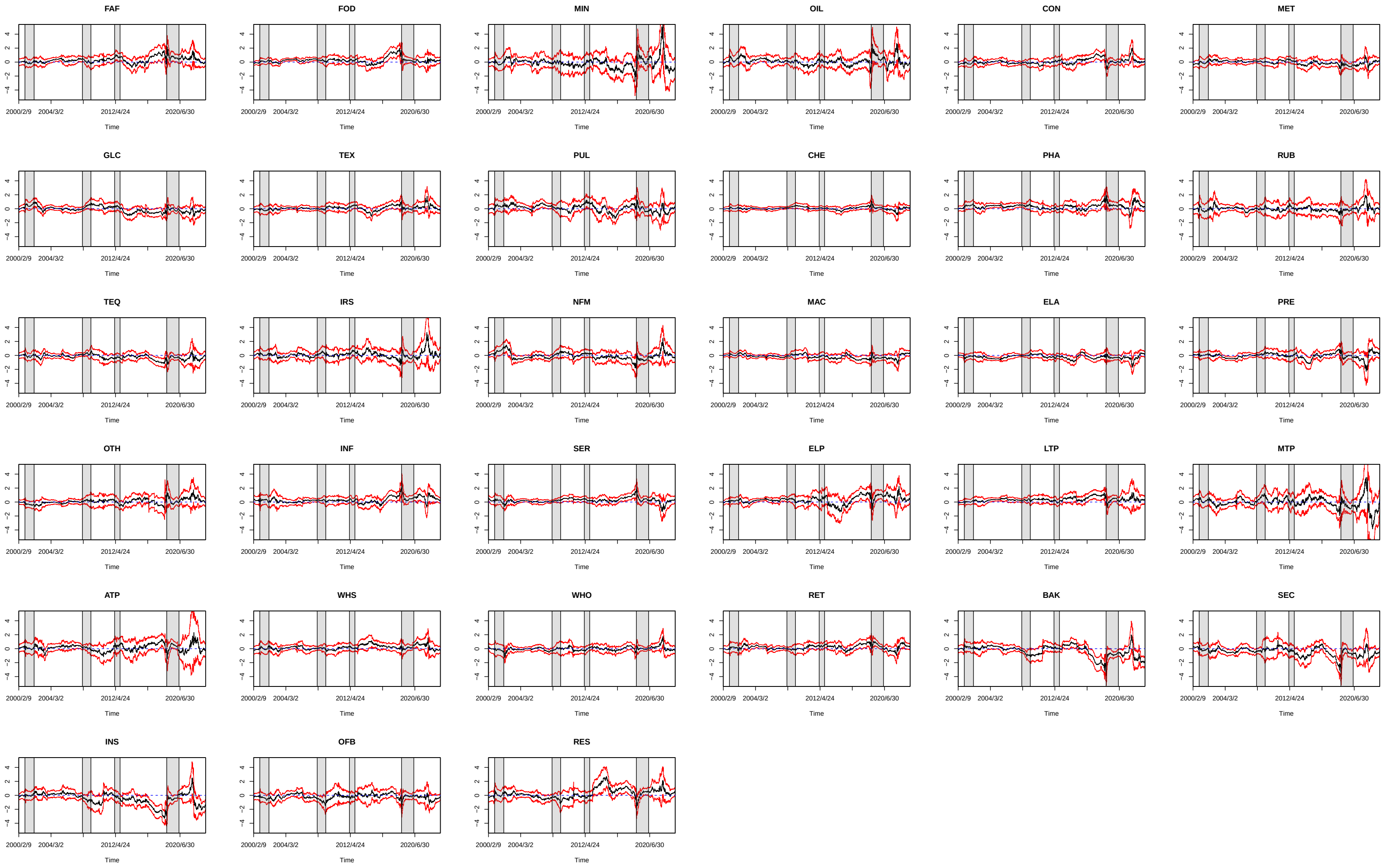
Note: As for Figure A.1.

Figure A.5: Time-Varying Estimates of $\hat{\boldsymbol{\beta}}_{CMD}$



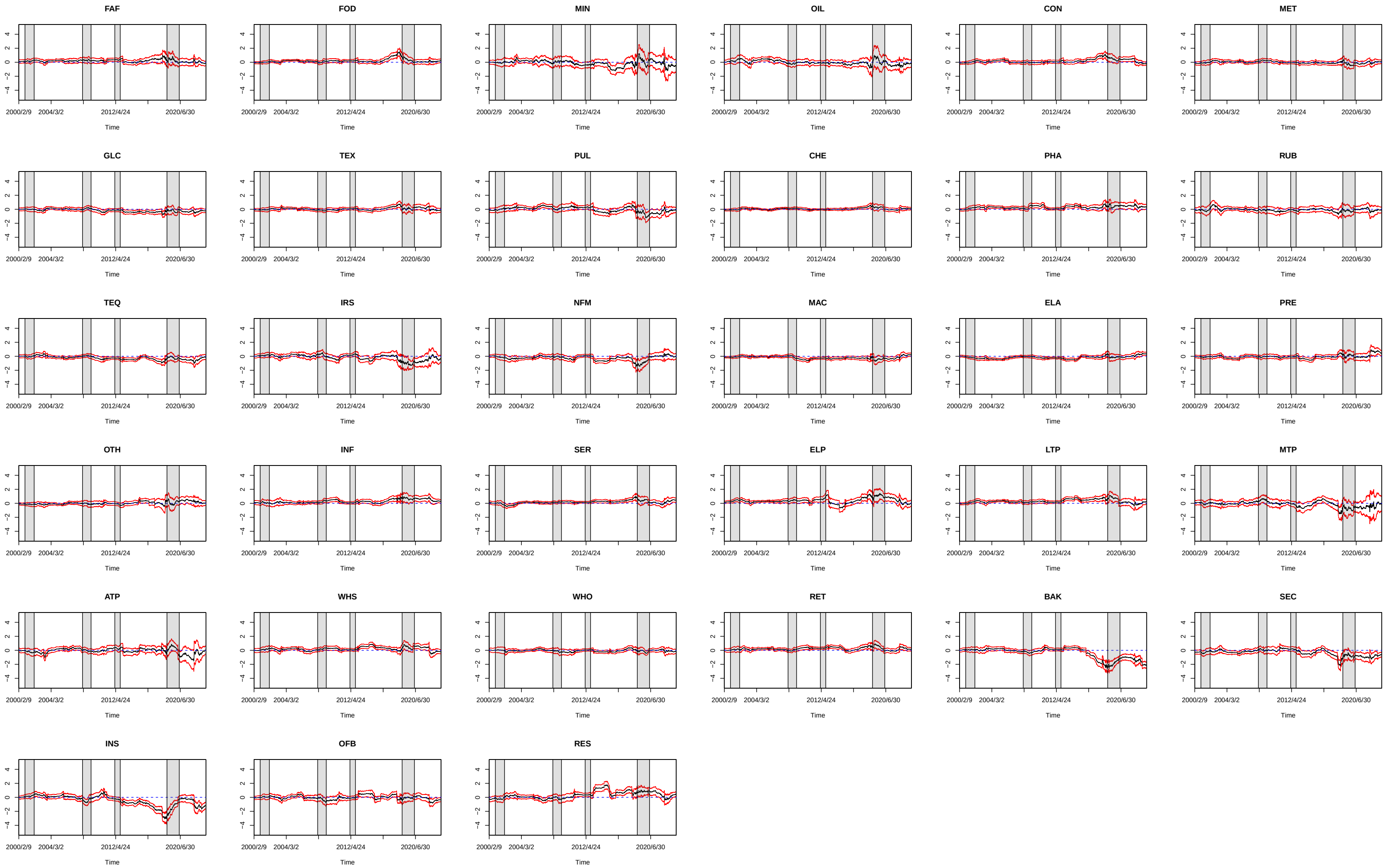
Note: As for Figure A.1.

Figure A.6: Time-Varying Estimates of $\hat{\boldsymbol{\beta}}_{UTS}$



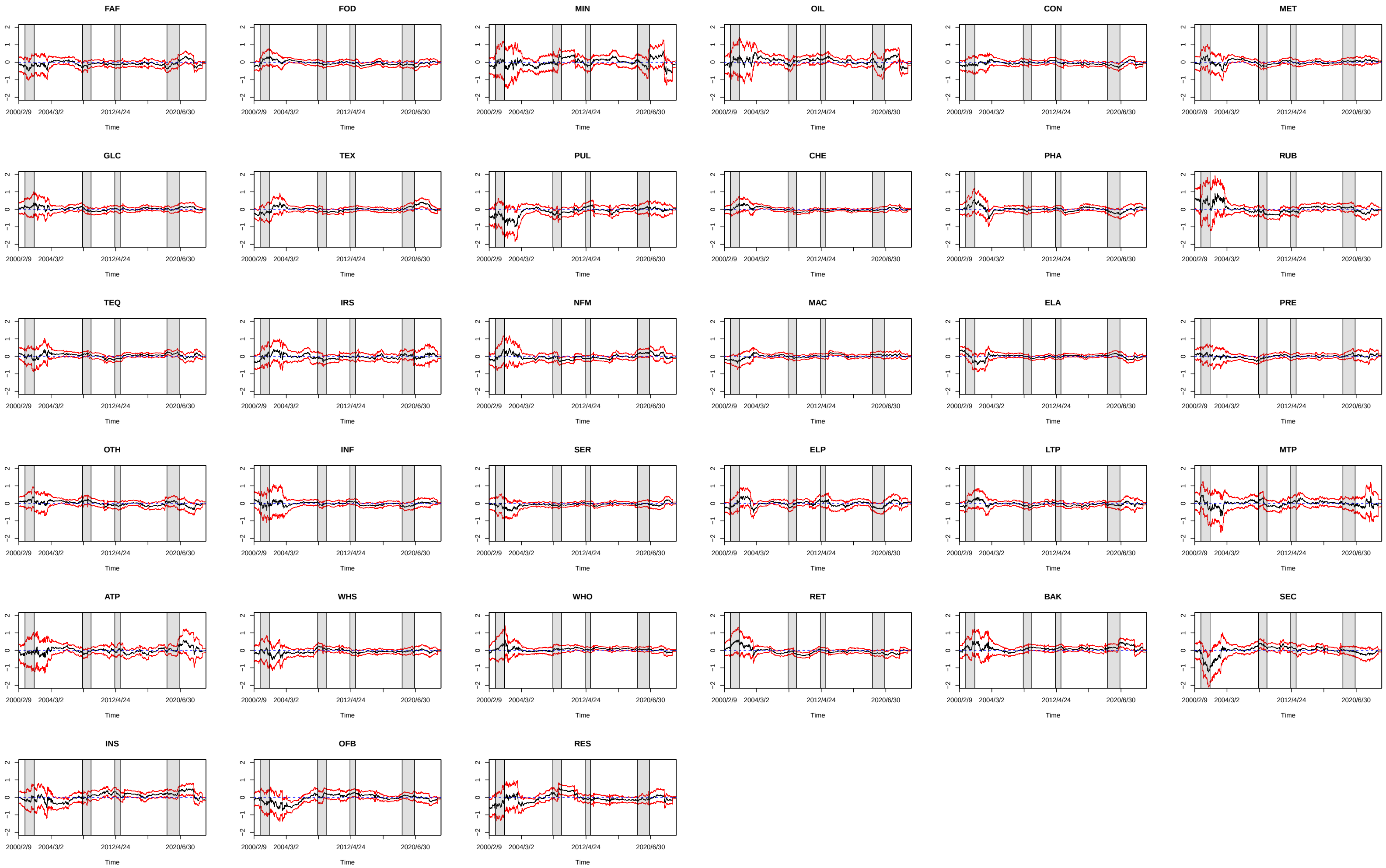
Note: As for Figure A.1.

Figure A.7: Time-Varying Estimates of $\hat{\boldsymbol{\beta}}_{RP}$



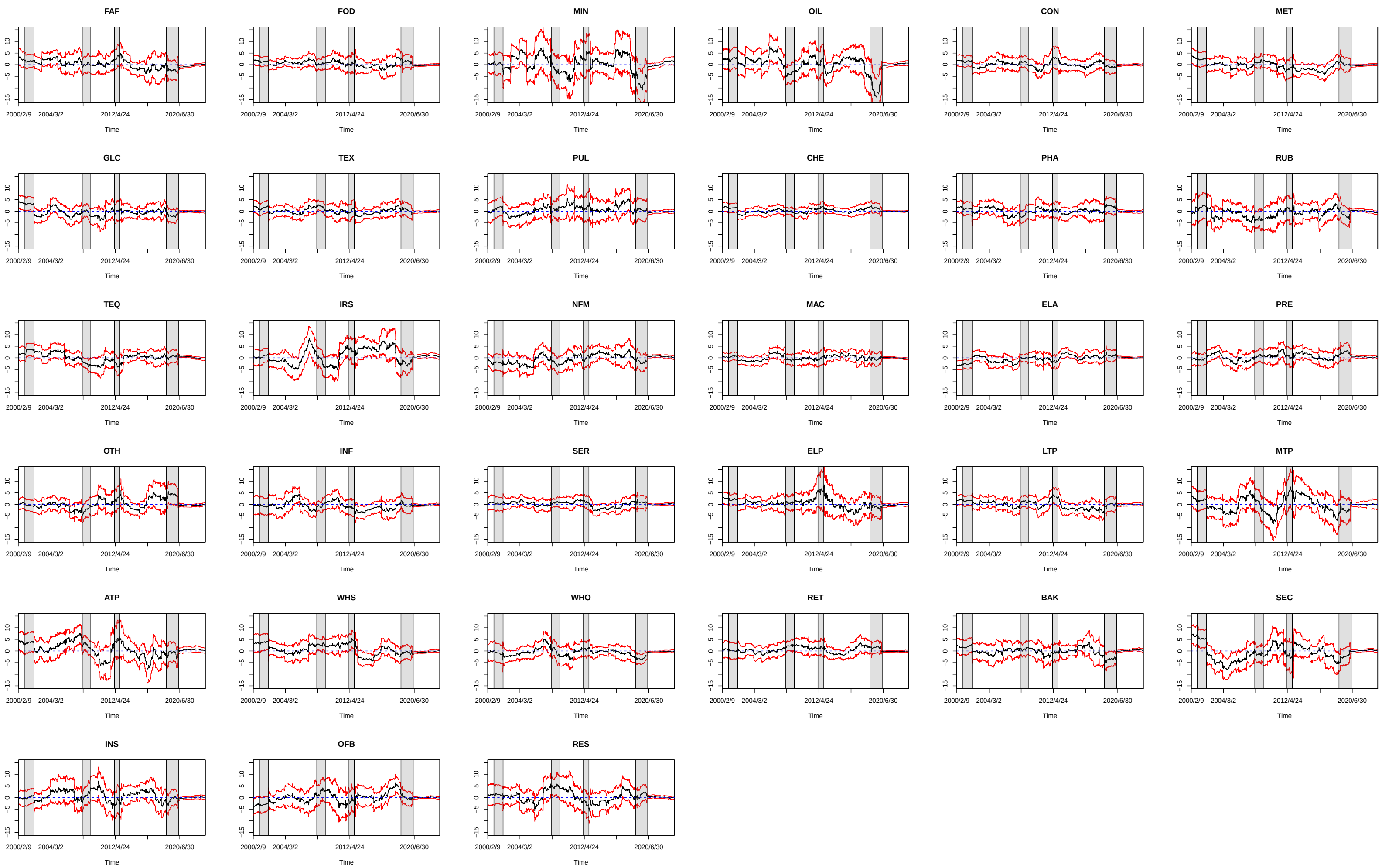
Note: As for Figure A.1.

Figure A.8: Time-Varying Estimates of $\hat{\boldsymbol{\beta}}_{UYEN}$



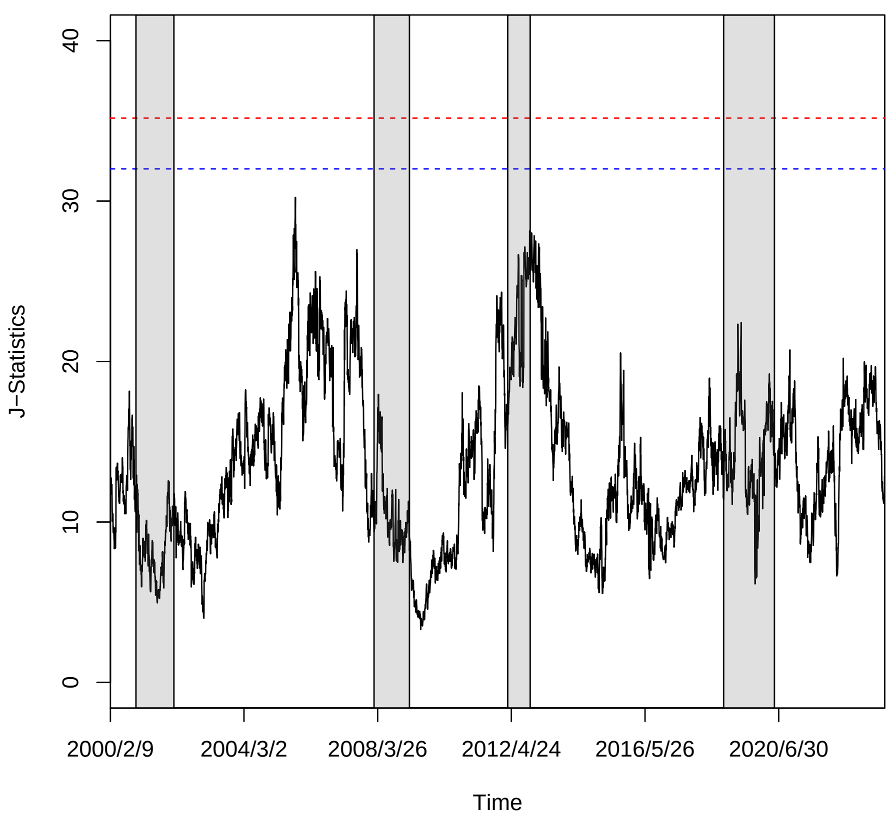
Note: As for Figure A.1.

Figure A.9: Time-Varying Estimates of $\hat{\boldsymbol{\beta}}_{UI}$



<u>Note:</u> As for Figure A.1.

Figure A.10: Time-Varying Hansen-Jagannathan Distance



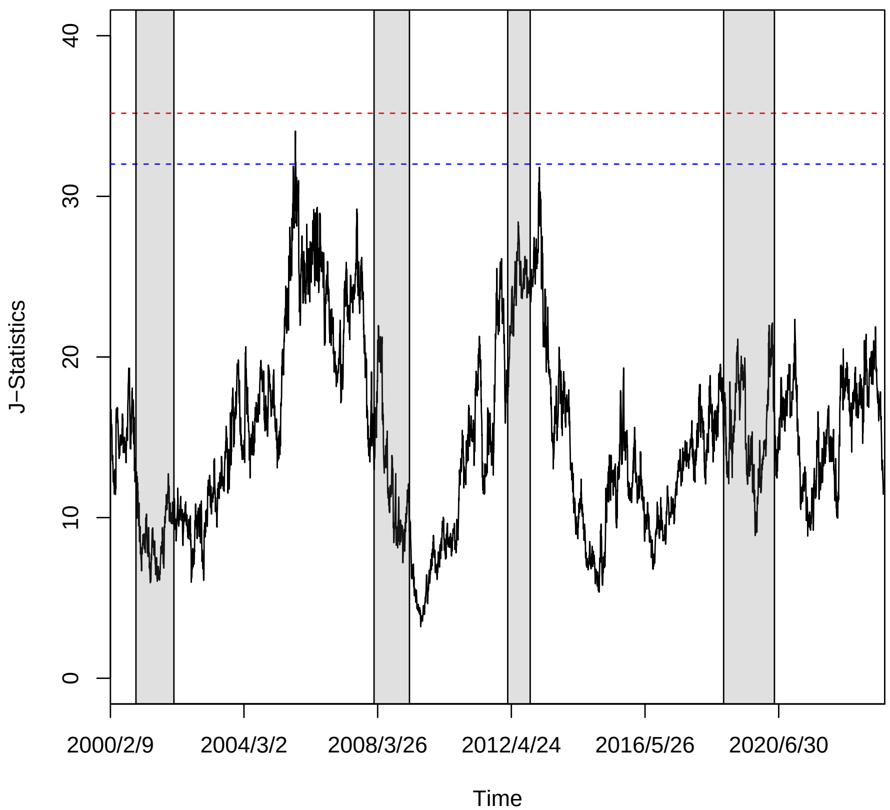
<u>Notes:</u>

(1) The dashed red and blue lines denote the critical value at the 5% and 10% significance levels for the HJ-distance, respectively.

(2) The shade areas are recessions as defined by the Cabinet Office Japan "Indexes of Business Conditions."

(3) R version 4.3.1 was used to compute the statistics.

Figure A.11: Time-Varying Bias-Corrected Hansen-Jagannathan Distance



Notes:

(1) The dashed red and blue lines denote the critical value at the 5% and 10% significance levels for the HJ-distance, respectively.

(2) The shade areas are recessions as defined by the Cabinet Office Japan "Indexes of Business Conditions."

(3) R version 4.3.1 was used to compute the statistics.