NPFC-2023-SSC PS12-WP05 (Rev.1)

Testing the sensitivity of BSSPM results to different prior assumptions of key model parameters

Libin Dai and Siquan Tian
Shanghai Ocean University

Background and Objective

The stock assessment of Pacific saury (*Cololabis sarira*) is regularly updated using a Bayesian state-space production model (BSSPM) by three members (China, Chinese Taipei, and Japan) of the Small Scientific Committee on Pacific saury (SSC PS). While some model parameters share unified prior assumptions among the three members, others are defined based on individual preferences (NPFC-2019-SSC PS09-Final Report). In the 11th SSC PS meeting, China and Japan employed flat prior distributions for free parameters, whereas Chinese Taipei utilized less informative priors for key parameters such as carrying capacity (*K*) and intrinsic growth rate (*r*). Despite utilizing the same input data, the dissimilarity in prior assumptions is considered a potential factor contributing to scale differences in the assessment results among the three members. This working paper aims to cross-check other members' code by testing the sensitivity of BSSPM results to different prior assumptions of model parameters.

Prior specification in BSSPM

The study tested two types of prior assumptions, as extracted from the BSSPM assessment reports of China (NPFC-2023-SSC PS11-WP15) and Chinese Taipei (NPFC-2023-SSC PS11-WP16), detailed in **Table 1**. The key distinction lies in the prior assumptions for parameters *K*, *r*, and P_1. Flat priors assume a uniform distribution for *K*, r, and *P1*, while less informative priors assume a lognormal distribution for these parameters. All other model specifications align between the two members and adhere to the recommendations from SSC PS09.

Results and Conclusions

We compared reference points (**Table 2-3**) and parameter estimates (**Table 4-5**) from two prior scenarios with those of Chinese Taipei's assessment report. We successfully reproduced the results of Chinese Taipei's BSSPM. Generally, Base case 1 is more robust to prior assumptions than Base case 2. Notably, key reference points (e.g., FMSY, *K*, and BMSY) in both Base case scenarios differed significantly between the two types of priors. **Figure 1-2** illustrate the comparison of posterior distributions from two prior specifications. Lognormal priors resulted in shorter tails in the posterior distributions of *r* and *K* in Base case 1 and Base case 2, respectively. In Base case 1, lognormal priors shifted the posterior distributions of *q* to the left. Time series plots (**Figures 3-7**) confirmed scale differences among members' assessment results due to different prior assumptions. Base case 2 showed sensitivity of absolute estimated biomass and harvest rate to prior assumptions, while relative quantities (B/B_{MSY} and F/F_{MSY}) remained robust. The use of lognormal (less informative) priors alleviated scale difference between the two base case scenarios. In conclusion, the BSSPM code from China and Chinese Taipei is cross-validated, and their assessments are reproducible. Scale differences among members' analyses stem from differing prior assumptions.

Acknowledgement

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References

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Table 1. Two types of prior specifications tested in this study.

Parameters	**Description**	**Flat priors (CHN)**	**Less informative priors (CT)**
K	Carrying capacity	U(63, 1890)	$K \sim \log N\,[\log(180) - \frac{\sigma_K^2}{2}, \sigma_K^2];\; CV_K = 2$
r	Intrinsic growth rate	U(0, 3)	$r \sim \log N\,[\log(1.2) - \frac{\sigma_r^2}{2}, \sigma_r^2];\; CV_r = 2$
s	Shape parameter	U(0, 3)	s~Gamma(2, 2)
qJPN	Catachability for CPUE_JPN2	U(0, 1)	$1/q$~Gamma(0.01, 0.01)
qRUS	Catachability for CPUE_RUS	U(0, 1)	$1/q$~Gamma(0.01, 0.01)
qCT	Catachability for CPUE_CT	U(0, 1)	$1/q$~Gamma(0.01, 0.01)
qKOR	Catachability for CPUE_KOR	U(0, 5)	$1/q$~Gamma(0.01, 0.01)
qCHN	Catachability for CPUE_CHN	U(0, 5)	$1/q$~Gamma(0.01, 0.01)
qJoint	Catachability for joint CPUE	U(0, 1)	$1/q$~Gamma(0.01, 0.01)
P_1	Initial condition	U(0, 1)	$P_1 \sim \log N\,[\log(0.7) - \frac{\sigma_{P_1}^2}{2}, \sigma_{P_1}^2]; CV_{P_1} = 1$
σ^2	Observation error	$1/\sigma^2$~Gamma(0.001, 0.001)	$1/\sigma^2$~Gamma(2, 0.45)
τ^2	Process error	$1/\tau^2$~Gamma(0.001, 0.001)	$1/\tau^2$~Gamma(4, 0.1)

Table 2. Comparison of summary of reference points from two prior specifications (Base case 1). All values are median.

	Flat priors	**Less informative priors (this study)**	**Less informative priors (CT report)**
AveF2020-2022	0.44	0.31	0.31
F2022	0.28	0.23	0.23
FMSY	0.43	0.31	0.30
MSY (10,000 tons)	42.75	38.61	38.58
F2022/FMSY	0.67	0.75	0.77
AveF2020-2022/FMSY	1.04	1.02	1.04
K (10,000 tons)	209.55	248.25	256.25
B2022 (10,000 tons)	35.37	43.25	43.94
B2023 (10,000 tons)	51.92	58.46	57.99
AveB2021-2023	36.86	45.10	45.50
BMSY (10,000 tons)	99.26	122.65	127.10
BMSY/K	0.47	0.49	0.50
B2022/K	0.17	0.18	0.17
B2023/K	0.25	0.24	0.23
B2021-2023/K	0.18	0.18	0.18
B2022/BMSY	0.35	0.35	0.34
B2023/BMSY	0.52	0.48	0.46
B2021-2023/BMSY	0.37	0.37	0.36

Table 3. Comparison of summary of reference points from two prior specifications (Base case 2). All values are median.

	Flat priors	**Less informative priors (this study)**	**Less informative priors (CT report)**
AveF2020-2022	0.22	0.33	0.32
F2022	0.18	0.25	0.25
FMSY	0.17	0.29	0.29
MSY (10,000 tons)	37.34	39.92	39.40
F2022/FMSY	1.08	0.87	0.86
AveF2020-2022/FMSY	1.35	1.15	1.13
K (10,000 tons)	469.50	274.10	265.40
B2022 (10,000 tons)	56.42	40.62	40.28
B2023 (10,000 tons)	65.43	52.53	52.33
AveB2021-2023	57.19	42.18	41.99
BMSY (10,000 tons)	219.25	135.90	133.50
BMSY/K	0.47	0.50	0.50
B2022/K	0.12	0.15	0.15
B2023/K	0.15	0.19	0.20
B2021-2023/K	0.13	0.15	0.16
B2022/BMSY	0.26	0.29	0.30
B2023/BMSY	0.30	0.39	0.39
B2021-2023/BMSY	0.26	0.31	0.31

Table 4. Comparison of summary of parameter estimates from two prior specifications (Base case 1). All values are median.

	Flat priors	**Less informative priors (this study)**	**Less informative priors (CT report)**
r	1.10	0.68	0.65
K	209.55	248.25	256.25
qCHN	1.10	0.33	0.40
qJPN2	0.17	0.05	0.06
qKOR	0.80	0.22	0.27
qRUS	0.09	0.03	0.03
qCT	0.18	0.05	0.06
qBio	0.62	0.50	0.49
Shape	0.70	0.94	0.96
sigma_com	0.07	0.28	0.19
sigma_Bio	0.03	0.12	0.09
tau	0.29	0.19	0.17
FMSY	0.43	0.31	0.30
BMSY	99.26	122.65	127.10
MSY	42.75	38.61	38.58
b	0.54	0.80	0.75

Table 5. Comparison of summary of parameter estimates from two prior specifications (Base case 2). All values are median.

	Flat priors	**Less informative priors (this study)**	**Less informative priors (CT report)**
r	0.54	0.63	0.61
K	469.50	274.10	265.4
qBio	0.34	0.49	0.48
qJoint	0.06	0.07	0.05
Shape	0.72	0.96	1.04
sigma_com	0.36	0.37	0.37
sigma_Bio	0.36	0.37	0.16
tau	0.09	0.16	0.16
FMSY	0.17	0.29	0.29
BMSY	219.25	135.90	133.5
MSY	37.34	39.92	39.4
b	0.53	0.54	0.62

Fig. 1. Comparison of posterior distributions from two prior specifications (Base case 1). The red lines denote flat priors and the blue lines represent less informative priors.

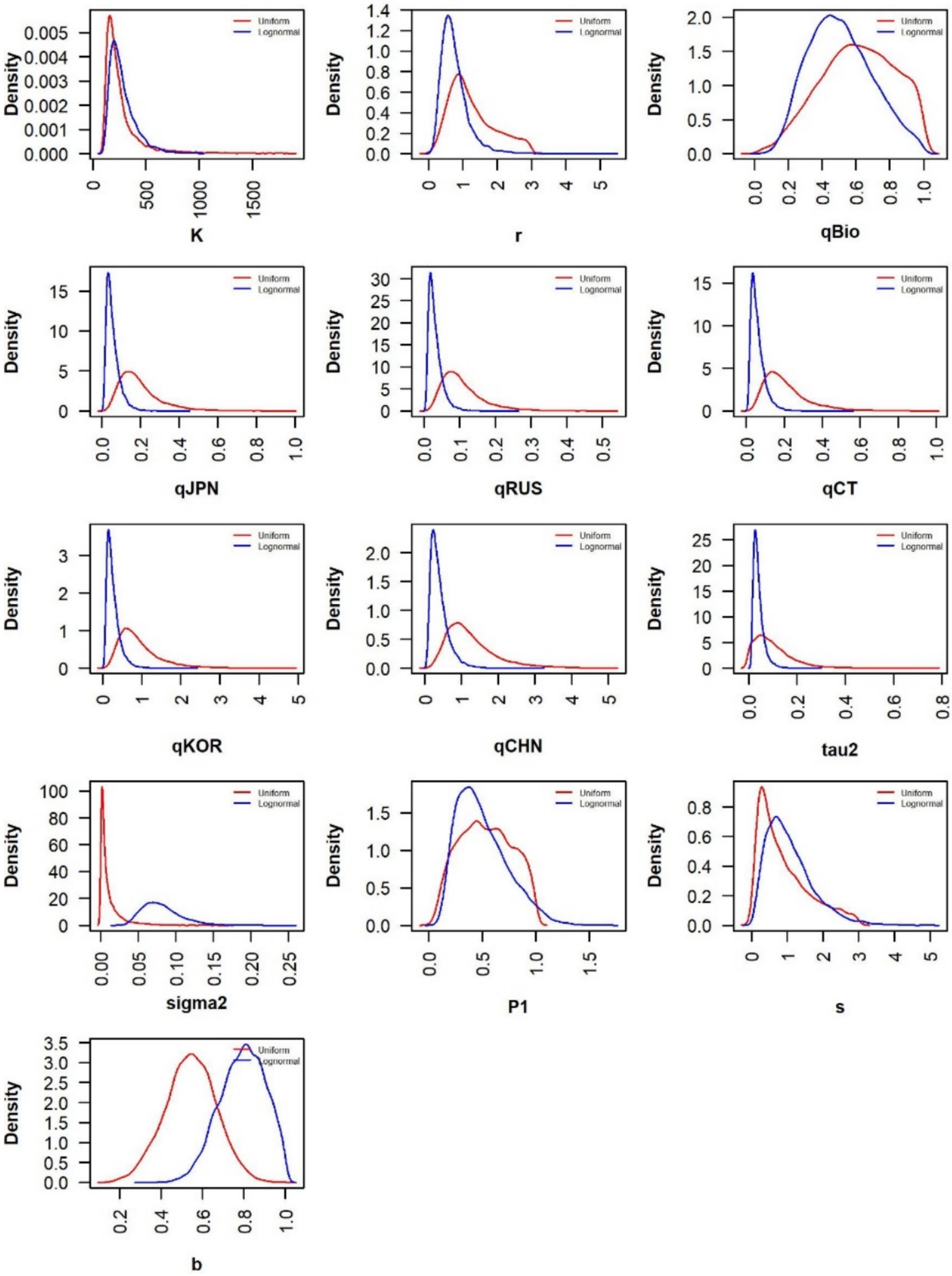

Fig. 2. Comparison of posterior distributions from two prior specifications (Base case 2). The red lines denote flat priors and the blue lines represent less informative priors.

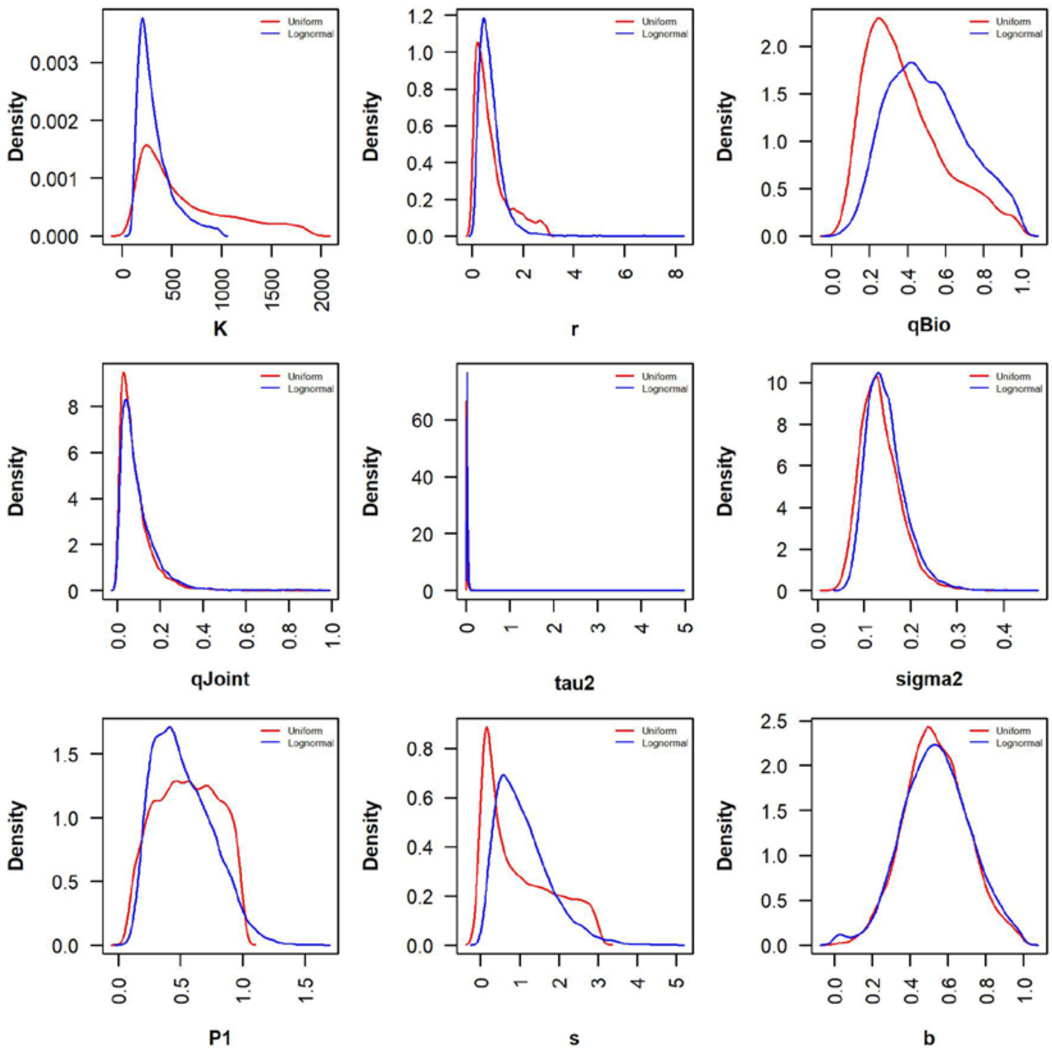

Fig. 3. Comparison of biomass time series from two prior specifications. The red lines denote flat priors and the blue lines represent less informative priors.

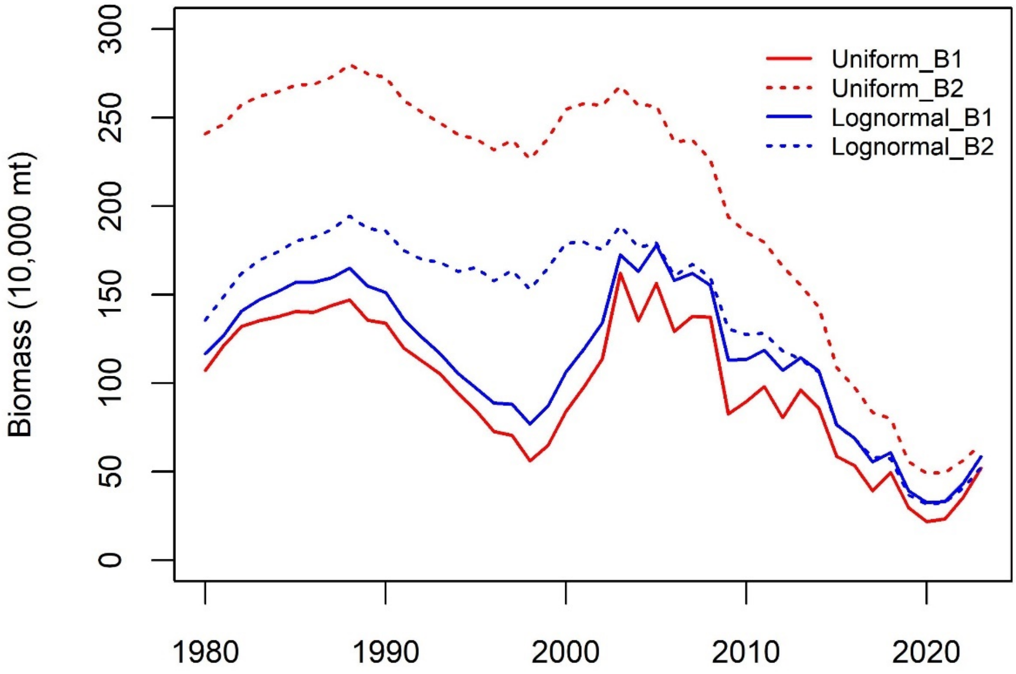

Fig. 4. Comparison of B/Bmsy from two prior specifications. The red lines denote flat priors and the blue lines represent less informative priors.

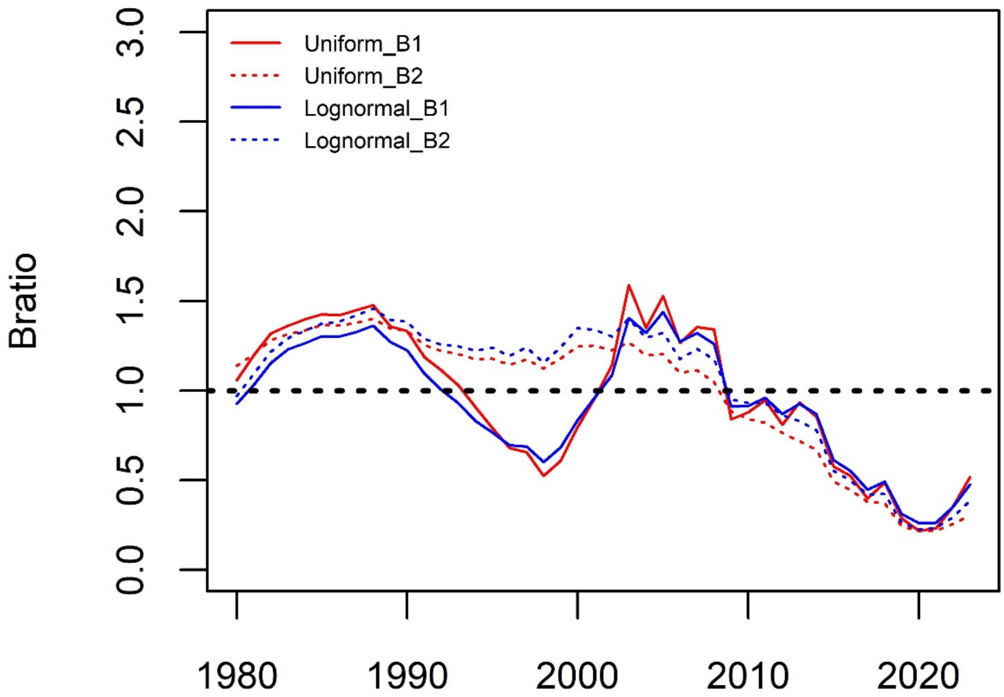

Fig. 5. Comparison of B/K from two prior specifications. The red lines denote flat priors and the blue lines represent less informative priors.

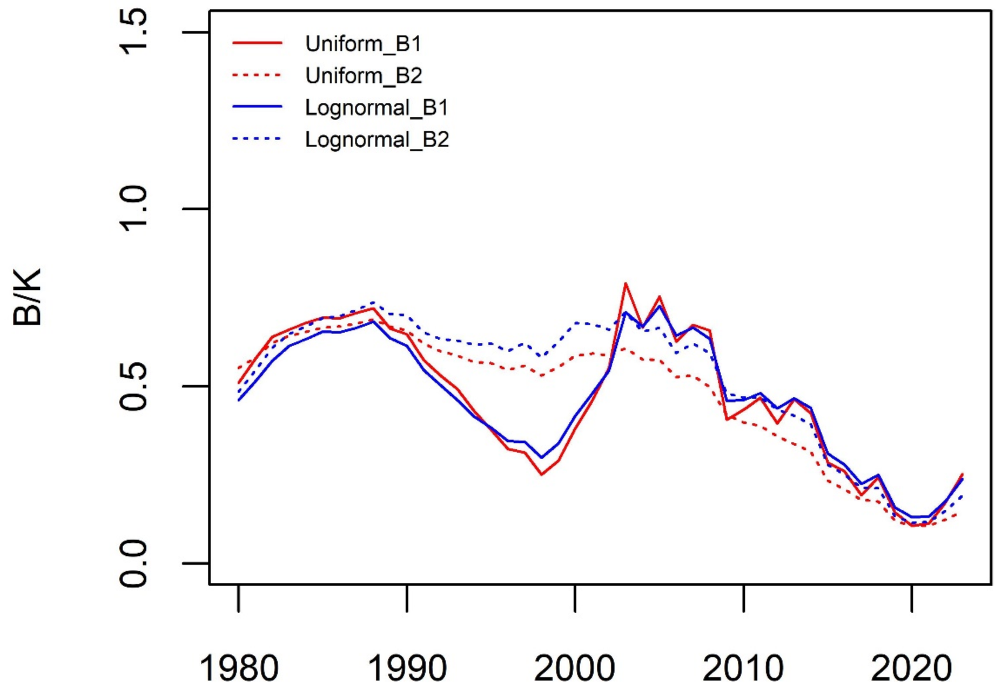

Fig. 6. Comparison of harvest rate time series from two prior specifications. The red lines denote flat priors and the blue lines represent less informative priors.

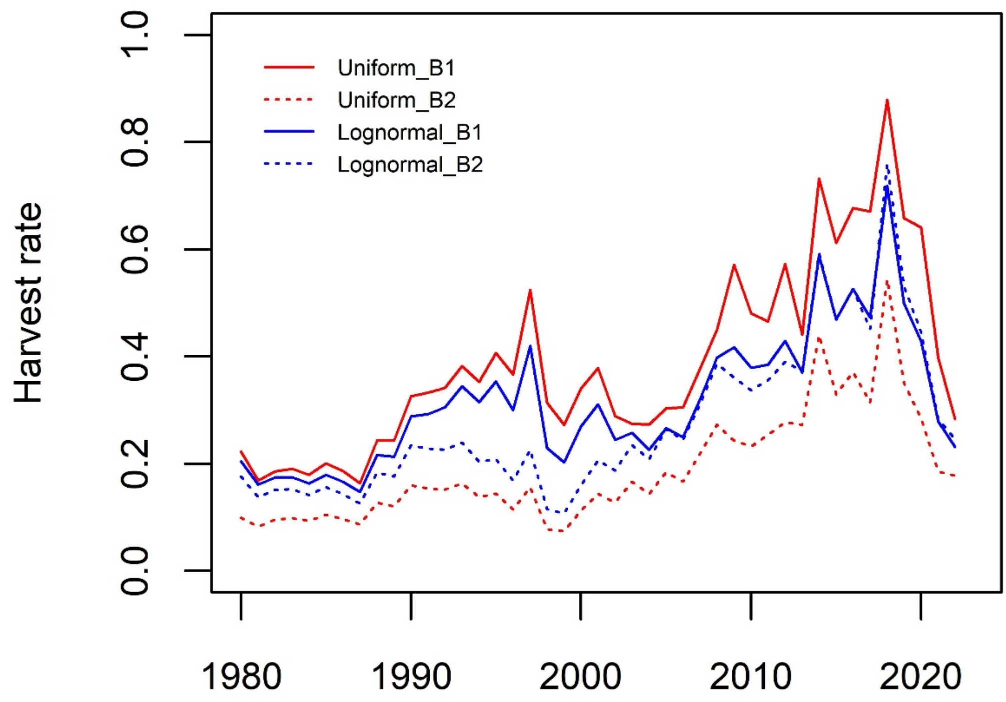

Fig. 7. Comparison of Fratio time series from two prior specifications. The red lines denote flat priors and the blue lines represent less informative priors.