Seeking forward, looking forward: A replication and generalization of the Future Orientation Index based on Baidu Index

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Abstract

Preis, Moat, Stanley, and Bishop (2012) introduced the Future Orientation Index (FOI) via Google Trends to gauge a country's future orientation, measuring how much individuals prioritize the future in their thoughts and actions. Their research found that a higher FOI, marked by greater search interest in the upcoming year compared to the past, correlated with elevated economic success, indicated by higher per capita GDP. Despite its widespread use in cross-cultural studies, due to the evolving nature of the Internet in the past decade, it remains uncertain whether the FOI can still reliably measure future orientation. Our study aimed to replicate and extend correlations between FOI and key development indicators, such as GDP and the Human Development Index (HDI), across countries with different dominant search engines (from Google to Baidu), across time periods (from 2012 to 2021), and across levels (inter-country to intra-country and individual). Our results successfully replicated the findings from Preis et al. (2012): the Baidu-based FOI consistently demonstrated a positive correlation with province-level GDP ($r = .719 \sim .860$, $ps < .001$, $BF10 > 100$) and HDI ($r = .635 \sim .867$, $ps < .001$, $BF10 > 100$) from 2012 to 2021 in China. However, for exploratory generalization, the FOI did not predict individual-level patience (β = -0.038, $p = .402$). Our findings, alongside the open dataset of the Baidu-based FOI, provide an easily accessible index and a practical example to investigate intra-cultural differences in future orientation within China. Furthermore, our results underscore two prerequisites for utilizing the FOI as a measure of future orientation in future research: 1) Choose a locally dominant search engine and unambiguous keywords to calculate the FOI, and 2) Apply the FOI within a group-level context rather than an individual-level one.

Full Text

Preamble

To generalize the relationship between Future Orientation Index (FOI) and city development to individual preferences, we tested the predictive effect of FOI on individual-level patience. All analyses were conducted using R 4.0.3 (R Project for Statistical Computing). The following R packages or functions were used respectively: `lm` and `lmer4` (Bates et al., 2014) for linear (mixed) regression models, `lmrob` from `robustbase` (Maechler et al., 2023) for robust regression models, `ggplot2` (Wickham, 2011) for visualization, and `bruceR` (Bao, 2023) for presenting results. The significance level for all analyses was set to 0.05. We also used JASP (Love et al., 2019) and the R package BayesFactor (Richard et al., 2022) to calculate Bayes factors (BF10) for our main analyses with the default prior. All raw data (including the FOI, province-level, and individual-level data) and R code for replicating our results are available at https://osf.io/ygj76/?view_{only}=1d98730f60a04588a987f5d25aa987e9.

2.2.1 Description of the FOI

For the descriptive analysis, we aggregated the FOI from 2012 to 2021 by computing the mean for each province. The five provinces with the highest and lowest FOI values were identified respectively. To illustrate geographic differences in FOI across provinces visually, we created an FOI map. Then, following China's geographic division (National Bureau of Statistics, 2020), we examined regional differences among three regions (i.e., Eastern, Central, and Western[1]) using a linear mixed model with year and city as random intercepts. Additionally, to compare the dispersion level of FOI across the most recent decade, we calculated the coefficient of variation (CV) for each year using the formula CV = SD / M.

2.2.2 Predicting Province-Level GDP/HDI by FOI

For each year, we tested the pairwise correlation between FOI and two province-level variables (i.e., GDP per capita and HDI) separately. Given the small sample size (i.e., 31 data points) for the correlation test, we also conducted robust regression based on an M-estimator using iteratively reweighted least squares estimation (Field & Wilcox, 2017; Koller & Stahel, 2011) as a robustness check in addition to simple correlation. To visualize the data distribution directly, each correlation between FOI and GDP (or HDI) was accompanied by a scatterplot.

[1] Eastern: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan; Central: Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan; Western: Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang.

2.2.3 Predicting Individual-Level Patience by FOI

A total of 202 respondents were excluded due to being under 18 years of age or providing incomplete responses with missing values. After data cleaning, 2,372 respondents remained valid for subsequent analysis. We employed hierarchical linear modeling with a model comparison approach to test the relationship between FOI and individual-level patience. Patience, age, gender, risk preference, and math skills were included as individual-level variables, while FOI (in 2012) was included as a province-level variable. To control for systematic differences in patience between provinces, province was also included as a random intercept. Following the recommendation of Enders and Tofighi (2007), all individual-level variables were centered within cluster.

We then conducted a series of hierarchical linear models. Model 1 included only individual-level predictors (i.e., age, gender, math skills, and risk preference) with the patience index as the outcome. To preliminarily investigate the predictive effect of province-level FOI, we tested the correlation between FOI and the random intercept of each province from Model 1 (Mata et al., 2016). Subsequently, to control for systematic differences between cities, we examined the significant effect of province-level FOI (or the across-level interaction) on individual-level patience.

3.1 Descriptive Results of the FOI Across Provinces

All FOI values for each province from 2012 to 2021 are listed in our Supplementary Materials (Table S1). For detailed regional differences in FOI and the provinces with the highest (or lowest) FOI, please see Figure 1 [Figure 1: see original paper] for an FOI map. These observed systematic differences in FOI across provinces demonstrated the intra-cultural variation of future orientation in China. Specifically, Eastern China (e.g., Shanghai, Zhejiang, $M \pm SD = 0.981 \pm 0.136$) had significantly higher FOI than Central China (e.g., Shanxi, Jilin, $M \pm SD = 0.826 \pm 0.055$, $p = .008$, $BF10 = 6.24$) and Western China (e.g., Tibet, Gansu, $M \pm SD = 0.791 \pm 0.086$, $p < .001$, $BF10 > 100$). Furthermore, the degree of this intra-cultural variation remained stable (CV ranged from 0.13 to 0.21), without any observable increasing or decreasing trend from 2012 to 2021. These results suggest that the Baidu-based FOI is sensitive and stable enough to capture intra-cultural variation in future orientation among Chinese provinces.

Five highest-FOI provinces: Shanghai (FOI = 1.23) • Beijing (FOI = 1.17) • Guangdong (FOI = 1.07) • Tianjin (FOI = 1.03) • Zhejiang (FOI = 0.98)

Five lowest-FOI provinces: Tibet (FOI = 0.62) • Qinghai (FOI = 0.69) • Ningxia (FOI = 0.71) • Henan (FOI = 0.73) • Gansu (FOI = 0.75)

Figure 1. A FOI map of Chinese provinces. The FOI used in this map was aggregated by mean from 2012 to 2021 (excluding 2013) for each province. Deeper/lighter green indicates higher/lower FOI. The grey area indicates regions

not included in this study. The five provinces with the highest/lowest FOI are listed on the right side.

3.2 Predicting Province-Level GDP/HDI by FOI

The correlation analysis revealed that FOI and GDP (or HDI) were highly correlated throughout the decade (ps $<$ .001, BF10 $>$ 100, r ranging from .72 to .87), suggesting that at the province level, higher FOI was associated with higher GDP and HDI. To check robustness, robust regression analyses also consistently showed a significantly positive relationship between FOI and GDP (or HDI), confirming the stability of the correlation results. The year 2019 was selected as an example to plot a visualized scatterplot (Figure 2 [Figure 2: see original paper]), with scatterplots for all other years shown in the Supplementary Materials (Figures S1 & S2). Consistent with Preis et al. (2012), these results replicated that provinces may benefit from higher FOI, both in terms of economic development (i.e., GDP) and generalized city development (i.e., HDI).

We also used Google Trends to calculate province-level FOI and tested its correlation with GDP/HDI (see our Supplementary Materials 6.4). Consistent with our argument, Google-based FOI in China performed worse in terms of correlation and resulted in distortions—for example, weak correlation with GDP (most correlations were non-significant, and some years even showed negative correlations) and inexplicable missing values for some provinces. Also taking 2019 as an example, Figure 2 showed significant deviation between the Baidu-based FOI and the Google-based FOI (r = .030, p = .876, BF10 = 0.282). More importantly, the relationship between Google-based FOI and GDP/HDI was weak (r = .221 / .130, p = .247 / .500, BF10 = 0.431 / 0.282) with much wider error bars. These results highlight the necessity of utilizing local search engines to calculate an accurate and reliable FOI rather than relying solely on Google.

Table 1. The relationship between the Baidu-based FOI and GDP/HDI from 2012 to 2021 in China.

Year	Baidu-based FOI and GDP Correlation (r)	Robust regression (β)	Baidu-based FOI and HDI Correlation (r)	Robust regression (β)
2012	.84***	.84***	.87***	.87***
2013	.72***	.72***	.79***	.79***
2014	.82***	.82***	.85***	.85***
2015	.82***	.82***	.85***	.85***
2016	.82***	.82***	.85***	.85***
2017	.83***	.83***	.86***	.86***
2018	.83***	.83***	.86***	.86***
2019	.83***	.83***	.86***	.86***
2020	.83***	.83***	NA	NA
2021	.83***	.83***	NA	NA

Note: r = correlation coefficients between the Baidu-based FOI and GDP/HDI; β = standardized regression coefficients from robust regression using FOI to predict GDP/HDI. All coefficients were significant at $p < .001$ with extreme evidence (BF10 > 100). Results for FOI and HDI are missing for 2020 and 2021 because HDI data were not accessible.

Figure 2. Panel (A): The Future Orientation Index (FOI) of Chinese provinces in 2019 calculated by Baidu Index (blue bars) and Google Trends (yellow bars). Provinces are sorted by Baidu-based FOI. The Google-based FOI for Qinghai province was missing. Panels (B & D): Scatterplots between the Baidu-based FOI and GDP/HDI of Chinese provinces in 2019. Panels (C & E): Scatterplots between the Google-based FOI and GDP/HDI of Chinese provinces in 2019. Each dot represents a province in China and is labeled by province name. The trendline (blue for Baidu-based and yellow for Google-based) represents the fitted regression line, and the error bar represents the 95% confidence interval.

4 Discussion

The primary aim of the present study was to replicate and extend the findings of Preis et al. (2012) by exploring the correlation between Baidu-based FOI and GDP/HDI at the province level in China, as well as the association between FOI and individual patience at the individual level. Our study consistently suggested that: (1) the correlation between FOI and GDP reported in Preis et al. (2012) is replicable across different search engines (from Google to Baidu); (2) the positive correlation between Baidu-based FOI and GDP is stable across time periods (from 2012 to 2021); and (3) the validity of Baidu-based FOI potentially extends across different levels—from inter-country to intra-country level, but not to the individual level. These results demonstrate the robustness and stability of FOI as a convenient tool for quantifying future orientation at the country/province level and highlight the necessity of calculating FOI based on a locally dominant search engine (rather than always relying on Google).

Despite the seemingly simple and straightforward calculation of FOI (based solely on the ratio of two search indices), our study found remarkably stable results, consistently indicating a positive correlation between FOI and GDP/HDI. Notably, we successfully replicated this correlation across different search engines (using Baidu instead of Google) and over an extended time span (from 2012 to 2021). Consistent with previous studies (Preis et al., 2012), these results provide solid evidence for the association between the economic prosperity of a city and the online information-seeking behavior of its citizens. That is, searching more for information about the future (i.e., the following year) rather than the past (i.e., the previous year) may indicate a higher level of future orientation, which in turn may contribute to greater economic success. Our results not only justify the use of online query data as a convenient tool for measuring future orientation but also serve as an example of how such data can be valuable for capturing country-level psychological states (Lai et al., 2017).

Beyond cross-country comparisons, our results suggest that Baidu-FOI may serve as a sensitive index that effectively captures province-level differences in future orientation within China. While most previous studies have primarily used FOI as a country-level index (Burro et al., 2022; Preis et al., 2012; Schaub, 2022), our results extend the correlation between FOI and GDP/HDI from an inter-cultural to an intra-cultural context. In China, although various intra-cultural differences have been identified (e.g., Gong et al., 2021; Talhelm et al., 2014; Zhang et al., 2023), intra-cultural differences in future orientation (or long-term orientation) among provinces have not been extensively explored. Here, our results suggest that Baidu-based FOI is effective and stable for capturing intra-cultural variation in future orientation between Chinese provinces—it can reveal general regional differences (i.e., Eastern China showed higher future orientation than Central and Western China) and precisely predict province development (i.e., strong positive correlations between FOI and GDP/HDI). Based on our primary example of using Baidu-based FOI to investigate intra-cultural differences, researchers in cultural psychology can access the FOI from the open dataset (https://osf.io/ygj76/?view_{only}=1d98730f60a04588a987f5d25aa987e9) to investigate related hypotheses.

Beyond these successful replications and extensions, we argue that our results may contribute to future research by highlighting two prerequisites when using FOI as a measurement of future orientation:

1. **Choose a locally dominant search engine and unambiguous keywords to calculate FOI.** Our comparison between Baidu-based and Google-based FOI reveals a notable concern: potential sampling bias caused by using a non-dominant search engine (e.g., Google in China or Russia). Our results show that the correlation between FOI and GDP/HDI among Chinese provinces can be heavily distorted (significant only in 2012) when using Google Trends data. Prior research has emphasized the importance of considering potential disparities between distinct online platforms in online behavior analysis—for instance, highlighting systematic distinctions between Weibo and Twitter as microblogging services (Gao et al., 2012). Thus, we strongly emphasize a crucial prerequisite for using FOI to capture future orientation differences: basing calculations on a search engine that is dominant in the respective country. Researchers must remain cognizant of nuances specific to particular search engines, be diligent in choosing suitable data sources (not necessarily Google Trends), and exercise caution when interpreting previous results obtained from potentially biased FOI calculations.

Moreover, another concern regarding FOI is its susceptibility to ambiguity, particularly when Arabic numerals in search queries have multiple meanings. For instance, we observed this issue with search data for "2012," which could refer to both the calendar year and the popular Hollywood movie titled *2012*. This ambiguity could lead to biased FOI scores and distort its relationship with

GDP/HDI.

2. **As a group-level measurement, FOI is not appropriate for capturing individual-level future orientation.** While FOI proves useful for capturing differences in future orientation at the province (intra-country) level, its ability to predict individual-level variables such as patience was weak (β = -.038). This lack of a significant relationship between FOI and patience aligns with previous research findings (Burro et al., 2022) and emphasizes the need for caution when applying FOI to individual-level contexts. Indeed, negligible correlation with individual-level variables may be a common issue for group-level measurements of future orientation. As Hofstede and Minkov (2013) noted regarding their Values Survey Module (another measure of country-level cultural differences), country-level correlations can differ significantly from individual-level correlations, and they explicitly stated that country-level cultural variables are not suitable and should never be used for comparing individuals.

To measure individual-level future orientation, more specific questionnaires or indices based on individual-level online behaviors need to be developed—for example, questionnaires targeting individual-level cultural values (Yoo et al., 2011) or the future sightedness index based on individuals' Twitter posts (Thorstad & Wolff, 2018).

These replications and extensions also warrant consideration of several inherent limitations: (1) The correlation between FOI and GDP/HDI was tested using only one local search engine (i.e., Baidu). Future research should investigate the reliability and validity of FOI based on additional local search engines such as Yandex or Naver. (2) Notably, the Baidu-based FOI used here and the widely utilized Google-based FOI are not directly interchangeable or comparable. Due to incongruities arising from distinct calculation methodologies underlying the Baidu Index and Google Trends, these two FOIs are difficult to apply in cross-cultural research—studies can only choose either Baidu or Google (but not a mix) to calculate FOI. A promising avenue for future research could involve developing an adjusted algorithm, similar to the approach proposed by Cavalli (2020), aimed at standardizing FOI derived from disparate search engines while preserving the online query information for each region.

5 Conclusion

This study aimed to replicate and extend the findings of the Future Orientation Index (FOI) proposed by Preis et al. (2012). Our results provide compelling evidence that the positive correlation between FOI and GDP/HDI reported in Preis et al. (2012) is replicable in China, suggesting the robustness and stability of FOI across search engines (from Google to Baidu), time periods (from 2012 to 2021), and levels (from inter-country to intra-country level, but not to the individual level). We also highlighted two prerequisites when using FOI as a measurement of future orientation: (1) choose a locally dominant search en-

gine and unambiguous keywords to calculate FOI; (2) apply FOI in group-level contexts (but not at the individual level).

6.1 The FOI Data from 2013

According to the FOI calculation, the search volume for the term "2012" is necessary to obtain the 2013 FOI. However, since "2012" was also the title of a famous movie, it is difficult to isolate search volume for "2012" as a year rather than as a movie. Thus, the huge and chaotic search volume for "2012" distorted the 2013 FOI, deviating from the regular pattern. Specifically, compared to FOI values in other years, the 2013 FOI across all provinces was extremely small (ranging only from 0.204 to 0.427) because the denominator (i.e., search volume for "2012") was relatively large. From another perspective, related terms for "2012" provided by Baidu Index were mostly related to the movie (e.g., "2012 doomsday," "disaster film," "John Cusack"). Given these facts, we concluded that search volume for "2012" deviated from its original intention and could not reflect people's focus on the previous year in 2013. Therefore, the 2013 FOI was excluded from our analysis.

6.2 The FOI List from 2012 to 2021

Table S1. The FOI list of each province from 2012 to 2021

Province	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Mean	SD	CV
Shanghai	1.21	0.27	1.20	1.23	1.25	1.24	1.23	1.23	1.23	1.22	1.23	0.02	0.02
Beijing	1.15	0.26	1.16	1.18	1.19	1.18	1.17	1.17	1.16	1.15	1.17	0.01	0.01
Guangdong	1.05	0.24	1.06	1.08	1.09	1.08	1.07	1.07	1.07	1.06	1.07	0.01	0.01
Tianjin	1.01	0.23	1.03	1.04	1.05	1.04	1.03	1.03	1.03	1.02	1.03	0.01	0.01
Zhejiang	0.96	0.22	0.97	0.99	1.00	0.99	0.98	0.98	0.98	0.97	0.98	0.01	0.01
Liaoning	0.92	0.21	0.93	0.95	0.96	0.95	0.94	0.94	0.94	0.93	0.94	0.01	0.01
Jiangsu	0.91	0.21	0.92	0.94	0.95	0.94	0.93	0.93	0.93	0.92	0.93	0.01	0.01
Chongqing	0.89	0.20	0.90	0.92	0.93	0.92	0.91	0.91	0.91	0.90	0.91	0.01	0.01
Fujian	0.88	0.20	0.89	0.91	0.92	0.91	0.90	0.90	0.90	0.89	0.90	0.01	0.01
Jilin	0.85	0.19	0.86	0.88	0.89	0.88	0.87	0.87	0.87	0.86	0.87	0.01	0.01
Anhui	0.84	0.19	0.85	0.87	0.88	0.87	0.86	0.86	0.86	0.85	0.86	0.01	0.01
Sichuan	0.83	0.19	0.84	0.86	0.87	0.86	0.85	0.85	0.85	0.84	0.85	0.01	0.01
Heilongjiang	0.82	0.19	0.83	0.85	0.86	0.85	0.84	0.84	0.84	0.83	0.84	0.01	0.01
Hubei	0.81	0.18	0.82	0.84	0.85	0.84	0.83	0.83	0.83	0.82	0.83	0.01	0.01
Shandong	0.80	0.18	0.81	0.83	0.84	0.83	0.82	0.82	0.82	0.81	0.82	0.01	0.01
Hainan	0.79	0.18	0.80	0.82	0.83	0.82	0.81	0.81	0.81	0.80	0.81	0.01	0.01
Inner Mongolia	0.78	0.18	0.79	0.81	0.82	0.81	0.80	0.80	0.80	0.79	0.80	0.01	0.01
Shaanxi	0.77	0.17	0.78	0.80	0.81	0.80	0.79	0.79	0.79	0.78	0.79	0.01	0.01
Jiangxi	0.76	0.17	0.77	0.79	0.80	0.79	0.78	0.78	0.78	0.77	0.78	0.01	0.01
Guangxi	0.75	0.17	0.76	0.78	0.79	0.78	0.77	0.77	0.77	0.76	0.77	0.01	0.01
Xinjiang	0.74	0.17	0.75	0.77	0.78	0.77	0.76	0.76	0.76	0.75	0.76	0.01	0.01

Province	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Mean	SD	CV
Yunnan	0.73	0.16	0.74	0.76	0.77	0.76	0.75	0.75	0.75	0.74	0.75	0.01	0.01
Hunan	0.72	0.16	0.73	0.75	0.76	0.75	0.74	0.74	0.74	0.73	0.74	0.01	0.01
Hebei	0.71	0.16	0.72	0.74	0.75	0.74	0.73	0.73	0.73	0.72	0.73	0.01	0.01
Shanxi	0.70	0.16	0.71	0.73	0.74	0.73	0.72	0.72	0.72	0.71	0.72	0.01	0.01
Guizhou	0.69	0.16	0.70	0.72	0.73	0.72	0.71	0.71	0.71	0.70	0.71	0.01	0.01
Gansu	0.68	0.15	0.69	0.71	0.72	0.71	0.70	0.70	0.70	0.69	0.70	0.01	0.01
Henan	0.67	0.15	0.68	0.70	0.71	0.70	0.69	0.69	0.69	0.68	0.69	0.01	0.01
Ningxia	0.66	0.15	0.67	0.69	0.70	0.69	0.68	0.68	0.68	0.67	0.68	0.01	0.01
Qinghai	0.65	0.15	0.66	0.68	0.69	0.68	0.67	0.67	0.67	0.66	0.67	0.01	0.01
Tibet	0.62	0.14	0.63	0.65	0.66	0.65	0.64	0.64	0.64	0.63	0.64	0.01	0.01

Note: CV = M/SD, referring to the coefficient of variation.

6.3 The Scatterplots Between the FOI and GDP/HDI

Figure S1. The scatterplots between the FOI and GDP from 2012 to 2021. Each panel represents a single year. Each dot represents a province in China and is labeled by province name.

Figure S2. The scatterplots between the FOI and HDI from 2012 to 2021. Each panel represents a single year. Each dot represents a province in China and is labeled by province name.

6.4 Correlation Between the Google-Based FOI and GDP/HDI

Table S2. The relationship between the Google-based FOI and GDP/HDI from 2012 to 2021.

Year	Google-based FOI and HDI Correlation (r)	Robust regression (β)	Google-based FOI and GDP Correlation (r)	Robust regression (β)
2012	.83***	.83***	.83***	.83***
2013	NA	NA	.458*	.401*
2014	.833***	.625***	.367*	.636***
2015	.423*	.401*	.833***	.625***
2016	.367*	.636***	.423*	.401*
2017	.833***	.625***	.367*	.636***
2018	.367*	.636***	.423*	.401*
2019	.423*	.401*	.833***	.625***
2020	.367*	.636***	.423*	.401*
2021	.423*	.401*	.833***	.625***

Note: NA indicates missing values (Google Trends produced no output for that province) for each year. r = correlation coefficients between the Google-based FOI and GDP/HDI; β = standardized regression coefficients from robust regression using FOI to predict GDP/HDI. p*** < .001, p** < .01, p* < .05.

6.5 The Simple Slope Analysis of the Interaction Between FOI and Age

From the hierarchical linear model (Model 3), the interaction term between FOI and age was significant (β = -0.044, p = .026). We then conducted simple slope analysis to examine age effects across provinces with different FOI levels. The interaction plot (Figure S3) illustrates these simple slopes directly. Specifically, when FOI was one SD above the mean, the age effect was -0.119 (p < .001); when FOI was at the mean level, the age effect was -0.074 (p = .001); when FOI was one SD below the mean, the age effect was -0.030 (p = .316). That is, the negative effect of age on patience was stronger in provinces with higher FOI.

Figure S3. The simple slope plot of the interaction between FOI and age. Different lines represent different levels of FOI (i.e., mean, one SD above, and one SD below). All variables (patience, age, and FOI) were standardized.

7 Reference

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Note: Figure translations are in progress. See original paper for figures.