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Moral attitudes towards effort and efficiency: a comparison between American and Chinese history

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In some cultures, merely exerting effort is considered virtuous, even when the effort is inefficient. Our study examines how this moral attitude towards effort (relative to efficiency) has evolved historically across two distinct sociopolitical and linguistic contexts: the People's Republic of China and the United States, using natural language processing techniques. Specifically, two formal political corpora were used—the *People's Daily* (1950–2021) and the Congressional speeches for the U.S. (1873–2011). We developed dictionaries for each concept based on pre-trained word embedding models in both languages. Moral attitudes towards effort and efficiency were calculated on a year-by-year basis as the cosine similarity between the dictionaries of these concepts and an existing dictionary of morality. We benchmarked the fluctuations of moral attitude towards inefficient effort against critical historical events in the two countries. Additional time series analysis and Granger tests revealed the association and potential directionality between the evolution of moral attitude towards inefficient effort and critical socio-cultural variables such as collectivism and cultural looseness. Our research sheds light on the historical and socio-cultural roots of moralization of effort and has implications for historical psychology research on moral attitudes.

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Introduction

Consider this scenario: A newspaper company recently adopted an Artificial Intelligence (AI) system capable of producing articles indistinguishable from those written by human journalists. The sale of the newspaper is unaffected after the company relies entirely on the AI system. Consequently, the two journalists employed by the company now benefit from indefinite paid time off (PTO). During this period, one journalist continues to write two articles daily as before, while the other spends their days lounging on the couch and watching TV. Who would you instinctively consider more morally praiseworthy? Recent work on moralization of inefficient effort has suggested that across multiple cultures, people tend to morally praise the individuals who exert efforts even when the efforts produce no discernible outcomes (Amos et al., 2019; Bigman and Tamir, 2016; Celniker et al., 2023; Ess and Burke, 2022; Fwu et al., 2014). In laboratory settings, individuals tend to infer positive moral attributes from a mere cue of effort (Amos et al., 2019; Celniker et al., 2023). Utilizing vignettes across various domains—including paid employment and partner choice—in different cultures, this line of research demonstrates that individuals who exert greater effort, even in tasks that appear meaningless and completely replaceable by less effortful alternatives, are perceived as more moral and deserving of higher monetary reward. Such a preference for effort has behavioral consequences. For example, the demonstration of effort exerted by fundraisers has been shown to increase participants' willingness to donate to the charity; participants were more likely to pay higher salaries to employees who exhibited more effort, even when the actual outcome or end product remains the same (Celniker et al., 2023).

The tendency to morally praise effort regardless of outcomes is observed not only in laboratory settings, but also seems to be a common theme in the workplace across many developed economies, where many high paying and prestigious jobs are deemed useless and meaningless (or "bullshit jobs") even by the employees holding those positions (Celniker et al., 2023; Graeber, 2018). A sociology work suggests that wealthy people in the U.S. tend to use their "hard work" to morally justify their advantageous socioeconomic status, while intentionally or unintentionally downplaying or ignoring the structural privilege they have (Sherman, 2017).

Interestingly, the consequences of moralization of inefficient effort may differ at the societal level compared with the individual level. While the dissociation between effort and efficiency can lead to negative individual consequences, such as diminished learning outcomes (Kirk-Johnson et al., 2019) and a lack of sense of meaningfulness (Graeber, 2018), it can serve a strategic role at the societal level. By valuing effort irrespective of outcomes, societies might encourage persistence and foster resilience in the face of challenges and setbacks. Such work ethics can pave the way for long-term innovation (Kundro, 2022) and stimulate economic growth (Becker and Woessmann, 2009), even if immediate results are not always evident. In short, the moralization of inefficient effort, in its ambivalent nature and its relationship to the societal environment, is more than merely justifying one's effortful actions but rather is linked to the evolution of moral systems and their intricate interplay with broader socio-cultural contexts.

Delving deeper into the moralization of inefficient effort, we could find its roots in a society's history and culture. Historically, many cultures have celebrated virtues such as diligence, perseverance, and hard work, often rooted in religious and/or philosophical teachings (Fitouchi et al., 2022). For instance, the Protestant Work Ethic (PWE) emphasizes labor and discipline as symbols of personal virtue (Weber, 1905). Empirical studies have shown that societies with a strong emphasis on PWE tend to value individual effort and achievement, even in secular contexts (Furnham, 1984; Uhlmann and Sanchez-Burks, 2014). Similarly, Confucian values from East Asia stress the importance of industriousness and constant self-improvement as moral obligations (Hwang, 2012). For example, in societies influenced by Confucian values (e.g., China, Korea), the education system is designed to reward effort-driven practices such as intensive memorization for exams. Here, students might internalize the belief that effort is a desirable goal in and of itself, a belief often reinforced by parents and educators (Chen, 2023). These cultural norms may have shaped societies to prioritize the exertion of effort itself over its outcomes, viewing genuine hard work as intrinsically valuable, regardless of its direct utility or efficiency.

Furthermore, differences also manifest in the perception and pursuit of efficiency. In the Confucian value system, equality is prioritized over individual efficiency (Poznanski, 2017). In contrast, the PWE not only promotes hard work but also views efficiency and individual achievement as means to achieve personal salvation (Weber, 1905). For example, compared to American families, Japanese families often promote task involvement through interpersonal cooperation rather than competition, often avoiding evaluations based on individual performance (Holloway, 1988).

In both cultures, the moral underpinnings of effort and efficiency are not just abstract values. They influence educational practices, social judgments, and even economic policies. However, traditional survey and experimental methods have limited capacity in revealing the historical roots and evolution of these moral attitudes at the societal level (Atari and Henrich, 2023; Muthukrishna et al., 2021).

Here, we aim to trace the moral values of effort and efficiency within two distinct sociopolitical and linguistic contexts - the United States and the People's Republic of China. We explore how these values evolved over time and how they interacted with key historical and economic trends. Our approach integrates natural language processing techniques and data from historical and contemporary sources, providing a robust and nuanced analysis of these complex moral constructs.

The historical and cultural perspectives. Rarely does any moral attitude remain static throughout history (Muthukrishna et al., 2021). Investigating the evolution of moral attitudes and the societal factors that influence and result from their changes can advance our understanding of cross-cultural and historical variations in human cognition. Studying these variations and their historical origins can provide insight into the fundamental aspects of human society, such as its values, ethics, and customs (Atari and Henrich, 2023; Schulz et al., 2019).

In the study of the evolution of moral attitudes, text corpora serve as an invaluable gateway into history, as it documents the collective minds of the human societies in the past (Muthukrishna et al., 2021). With the recent trend of applying computational linguistic models to historical text corpora, psychologists can reveal theoretically intriguing and hitherto neglected historical evolutions of various cultural and social constructs. For example, previous studies have identified a rise in individualism and the loosening of cultural norms within U.S. society over the past two centuries (Greenfield, 2013; Jackson et al., 2019). Adopting a similar approach, Choi and colleagues track the changes in the use of threatening language in American English books, and show that these changes correspond with actual threats in the U.S. history (Choi et al., 2022). Other studies have documented the surge of language use that is associated with

cognitive distortion, such as overgeneralizing and mislabeling, in American English, Spanish, and German books since the 1980s, and shown that this pattern is not driven by linguistic shifts (Bollen et al., 2021).

This line of work typically relies on the frequency of a set of words (i.e., a dictionary) that represents the psychological construct in question in large language corpora (e.g., Google Book) across time (Michel et al., 2011). A second approach for studying historical psychology employs co-occurrence analysis. By rating language proximal to specific terms based on psychological constructs, such as positivity and stereotypes, researchers can gain insights into the increasing negativity of attitudes toward older adults across time and ambivalent age stereotypes across cultures (Mason et al., 2015; Ng and Chow, 2021). More recent research leverages a natural language processing (NLP) technique, word embeddings, to measure semantic similarities between psychological constructs of interests, and to examine the historical evolution of such semantic similarities. This approach is based on the distributional hypothesis from linguistics, which posits that the semantic contexts around words capture their meaning in terms of cultural associations (Sahlgren, 2008) and has been shown to align well with human implicit bias data (Caliskan et al., 2017). Existing research has demonstrated its usefulness in capturing historical dynamics of social group representation (Cao et al., 2024; Charlesworth et al., 2022), identifying polarized framing of immigrants between political parties' speeches (Card et al., 2022), tracking the decline of gender and ethnic stereotypes in American historical corpora (Garg et al., 2018; Jones et al., 2020), as well as the consistency of gender stereotypes across child and adult corpora (Charlesworth et al., 2022).

Similar to the various psychological constructs reviewed above, cross-cultural diversity in moral attitudes in today's world is likely a consequence of distinct historical evolution trajectories in different geographic, linguistic, and social contexts (Henrich, 2020). Existing NLP-based historical psychological research has largely been focused on the so-called Western, Educated, Industrial, Rich, and Democratic (WEIRD) societies, and has primarily relied on English texts. While there are exceptions that use non-English sources such as German and French (Baumard et al., 2022; Bollen et al., 2021; Martins and Baumard, 2020), the Eurocentric focus in previous research has constrained the exploration of broader cultural and historical diversity. Here, we examine and compare the historical evolution of moral attitudes toward effort and efficiency in modern history of China and the U.S., two societies significantly differ in their political and economic institutions, popular cultures, ideologies, and languages. This allows us to identify similar and distinct societal and cultural drivers behind the different evolution trajectories. The rationale for focusing on these two cultures and languages is twofold. From a theoretical perspective, China and the U.S. are known to differ in important political structures, cultural values, and social norms, such as collectivism/individualism and cultural tightness/looseness (we acknowledge that cultural and social norms also differ significantly within each country) (Talhelm and English, 2020). More importantly, the two cultures also differ in their dominant work ethic (Amos et al., 2019; Celniker et al., 2023; Zhang et al., 2012): while the U.S. work ethic is strongly influenced by Protestant Work Ethic (PWE) beliefs (industrious, ambitious, hardworking, intrinsically motivated), the Chinese work ethic reflects Confucianism values (e.g., hard work, diligence, frugality, and the love of education). It is thus theoretically interesting to examine how the evolution of moral attitudes towards effort and efficiency/productivity differs in these two distinct cultures (e.g., as the economic performance of the society fluctuates). From a pragmatic perspective, Chinese is one of the most widely used non-alphabetical texts, yet it is digitally disadvantaged and underrepresented in natural language processing research (Zaugg et al., 2022). The text corpus that we adopted in this study spans the entire history of the People's Republic of China. Sharing the diachronic word embeddings based on this corpus will provide materials for future NLP-based historical psychology research.

Specifically, we set out to address three novel research questions and goals: (1) developing a computational linguistic tool targeting moral attitudes toward effort and efficiency expressed in Chinese and English texts; (2) characterizing the historical evolution trajectories of moral attitudes toward efforts and efficiency in modern Chinese and U.S. histories; and (3) understanding the social and cultural antecedents and consequences of the moral attitudes toward efforts and efficiency in both cultures.

Methods

Dictionary development. To capture the concepts of effort and efficiency in text data, we followed the procedure of several recent studies and developed dictionaries (i.e., word lists) representing the concepts of effort and efficiency. To this end, we employed a combination of pre-trained language models and human ratings, following the procedures of previous studies (Choi et al., 2022; Jackson et al., 2019; Lin et al., 2022). The process consisted of the following four main steps.

First, we identified English and Chinese seed words related to effort and efficiency from WordNet (Miller, 1995), a comprehensive lexical database and thesaurus.

Second, we computed the mean vector coordinates of the seed words using models pre-trained on datasets including Google News (Mikolov et al., 2013), Wikipedia (Bojanowski et al., 2017), and Twitter (Pennington et al., 2014) for English, and Renmin Web (people.cn), Wikipedia, and Weibo for Chinese (Li et al., 2018). This way, we located the seed words in high-dimensional semantic spaces and identified semantically similar terms. The selection of these pre-trained models was based on their coverage across diverse platforms, spanning traditional mass media, social media, and encyclopedism references. The rationale of using a more diverse set of corpora (as opposed to the corpora used for the main analyses) for dictionary development is to obtain a representative and generalizable linguistic indicator of the underlying constructs. The corpora used for the main analysis (i.e., *People's Daily* and Congressional speeches) was chosen partly due to their well-preserved temporal information and historical continuity. However, these corpora are limited in the contents, genre, and scope. Therefore, we believe that basing our dictionary development on a more comprehensive linguistic source is more appropriate and useful for future research.

Third, we extracted the 50 words closest to the mean coordinates of the seed words in each pre-trained model. These words were considered closely related to the concepts. None-words, duplications, and very low frequency words were filtered out before the next step.

Finally, two native speakers of English and two native speakers of Chinese from the research team were trained to evaluate the remaining candidate words for conceptual relevance to the concept in question on a scale of 1 (*not at all relevant*) to 5 (*extremely relevant*). Then, we selected the words that had an average rating higher than 3. Within this selection, certain words were excluded despite meeting the rating criterion due to reasons such as being very similar to other terms in the dictionaries, a low frequency of occurrence, consisting of multiple tokens, or ambiguous interpretations. The inter-rater reliability for the relevance ratings, assessed using the Intraclass Correlation Coefficient (ICC), demonstrated good reliability for effort in both English (ICC = 0.88) and Chinese (ICC = 0.76) and

moderate reliability for efficiency in English (ICC = 0.67) and Chinese (ICC = 0.51). We acknowledge that the ICC for the Chinese efficiency words was not great and therefore, the interpretations related to efficiency in the Chinese context should be taken with caution. The final dictionaries consisted of 10 words each for effort and efficiency in English, while the Chinese versions incorporated 13 for effort and 10 for efficiency. For the effort dictionary in Chinese, we include three additional words because four words positioned tenth in the relevance ratings which are all highly relevant to the concept and the overall cosine similarity between groups of words should not be significantly impacted, as the embedding process inherently normalizes these frequency effects. Some examples of the effort dictionary are "effort", "toil", and "perseverance". The efficiency dictionary comprises words like "efficiency," "productivity", "effective", "economical", and "profitable". Some examples of the Chinese effort dictionary are "努力", "力求", and "尽力", and some examples of the Chinese efficiency dictionary are "效益", "效率", and "效用". The complete list of candidate words and their ratings can be found in Supplementary Tables 1–4.

Calculating the moral values of effort and efficiency concepts. To represent positive and negative moral values, we used the word lists (i.e., dictionaries) from the Moral Foundations Dictionary 2.0 (Frimer et al., 2019), which is based on the Moral Foundations Theory (Graham et al., 2013). Some examples of these words, which are rooted in moral foundations (care, fairness, loyalty, authority, and sanctity), include "compassion", "equality", "loyalty", "respect", and "purity". The Chinese Moral Foundations Dictionary was adapted and translated from English to Chinese. The ability of this Chinese version to effectively capture moral values in Chinese texts has been validated in previous work (Chen et al., 2024; Garten et al., 2018). We acknowledge that various versions of the Moral Foundations Dictionary exist, both in English and Chinese (e.g., the Extended Moral Foundations Dictionary, (Hopp et al., 2020); the Chinese Moral Foundations Dictionary 2.0, (Cheng and Zhang, 2023)). We chose MFD 2.0 over MFD 1.0 because the former offers a more comprehensive set of moral terms (Kennedy et al., 2021b). MFD 2.0 contains five moral foundations, which is comparable to the Chinese moral foundations dictionary we used. We noted that different versions of Moral Foundations Theory have slightly different numbers and demarcation of the exact moral foundations (Atari et al., 2023; Graham et al., 2013; Hofmann et al., 2014). However, in this study, we did not test hypotheses specific to any single foundation. For the Chinese dictionary, the Chinese Moral Foundation Dictionary 2.0 is one of the most recent endeavors in creating a computational linguistic measure of morality in Chinese text (Cheng and Zhang, 2023). However, the researchers who developed this dictionary specifically argued that their dictionary did not distinguish between positively and negatively valenced moral words within each foundation, a feature that would be critical to our method (see below for details). Our choice of the dictionaries was based on the considerations of compatibility and ease of comparison between the English and Chinese analysis. We demonstrated the validity of the moral dictionaries in a validation analysis, where we benchmarked the fluctuations of the moral attitudes toward the U.S.S.R. in the Chinese and American corpora (see *Dictionary Validation* in the "Results" section).

Data collection and model training. To examine the societal attitudes toward effort and efficiency, we compiled two datasets from the U.S. Congressional speeches from 1873 to 2011 and *People's Daily* from 1950 to 2021. The United States

Congressional Record includes all speeches delivered on the floors of the United States House of Representatives and the United States Senate, encompassing a wide range of discussions and debates on various policy issues, reflecting the diverse views of American lawmakers. The content includes legislative activity, committee reports, member remarks, petitions, and memorials. We use the bound edition, a permanent, edited version of the daily records of congressional proceedings from the 43rd to the 111th Congress. This corpus has provided a reliable source to study sentiments and partisanship changes in the political context over time. For example, the congressional speeches have become increasingly positive and sentimental (Tucker et al., 2020). While the partisanship in the speeches remained stable and has become more polarized in recent decades (Enke, 2020; Gentzkow et al., 2019), parties not in power used more moral language (Wang and Inbar, 2021).

People's Daily is the official outlet of the Chinese Communist Party and reflects a crucial perspective on the Party's official stance on effort and efficiency in the context of their political and socio-economic environment. It features government policies, economic plans, societal issues, notable events, and official statements. Despite the structural changes in 1956, including the shift from traditional Chinese to simplified Chinese characters, the change in writing format from vertical to horizontal, and the expansion from 8 to 12 pages, the content and genre of the corpus remain stable over time. In that sense, this corpus has good temporal and generic continuity and covers almost the entire period of the People's Republic of China.

The corpora were split by year and trained into word2vec models using python *gensim* package with its default hyperparameter settings. The U.S. Congressional speeches corpus has a mean token count of 13.4 million per year with a standard deviation of 6.8 million, ranging from 867,210 to 29,252,016 tokens. The *People's Daily* corpus has a mean token count of 12.3 million, with a standard deviation of 5.9 million, ranging from 5,292,965 to 31,038,064 tokens. Year-by-year distribution of token counts across years is displayed in Supplementary Fig. 1. We employed the following key model hyperparameters: a vector size of 100, which determines the dimensionality of the word vectors; a window size of 5, which defines the maximum distance between the current and predicted word within a sentence; a minimum count of 5, meaning that words occurring less frequently than this threshold were ignored; a negative sampling rate of 5, which specifies the number of "noise words" to be drawn for each target word during training; and a number of iterations (epochs) as 5. The models were trained using the Skip-gram architecture, which is effective for capturing the context of a word in a large corpus. Word2Vec models provided a robust framework for generating meaningful word embeddings, facilitating our subsequent analyses of moral values in the textual data.

Measuring moral values in text corpora. To assess the moral values of effort and efficiency in the above corpora, we adopted the word embeddings bias method, a natural language processing technique widely used in previous studies that quantifies changes in stereotypical bias throughout the U.S. history (Charlesworth et al., 2022; Garg et al., 2018). First, our analysis required dictionaries representing the concepts of interest, including effort, efficiency, and moral values, detailed in *Dictionary Development* section above.

Second, to measure bias in word embeddings, we computed the strength of association (or similarity) between the dictionary of a concept (e.g., effort) and the dictionary of the evaluative words (e.g., moral virtues). Specifically, we calculated the average cosine

similarity between each concept (effort or efficiency) and the evaluative words, as shown in the formula below:

$$\text{Sim}_{(effort, virtue)} = \frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} \cos\left(\mathbf{V}_{effort_i}, \mathbf{V}_{virtue_j}\right)$$

Here, $\text{Sim}_{(effort, virtue)}$ represents the average cosine similarity between the effort concept and positive moral values (virtue), while M and N denote the total number of words in the two dictionaries. We used the same approach to calculate the negative moral values (vice) of effort and efficiency. Moral attitude towards effort (or efficiency) is defined as the difference between the positive and negative moral values of effort (or efficiency). Hereafter, we use Effort and Efficiency to denote the moral attitudes towards effort and efficiency, respectively. Moral attitude toward inefficient effort is defined as the difference between the positive moral value of effort and the positive moral value of efficiency. Hereafter, we use Inefficient Effort to denote the moral attitudes towards inefficient effort. This operationalization construes Inefficient Effort as the bias in a society's positive moral attitudes (i.e., virtue) toward effort relative to the positive moral attitudes toward efficiency. In other words, if a society values efforts precisely because of the outcomes the efforts produce (i.e., efficient effort), then the positive moral attitudes toward efforts should be comparable to the positive moral attitudes towards efficiency, in which case, the bias as we define it would be close to zero. On the other hand, if the bias is positive, then this implies that in such a society, efforts are valued over and beyond the outcome they produce. We refer to this additional positive moral value of effort as the moral value toward inefficient effort (i.e., efforts that do not produce outcomes). This "bias" approach is a standard practice in dictionary-based NLP work, such as stereotypes of groups (i.e., difference in semantic similarity between group names and positive/negative trait words (Charlesworth et al., 2022, 2024)), women's occupation bias (i.e., difference in semantic similarity between occupation names and women/men words (Garg et al., 2018)).

Other variables. To investigate the relationships between socio-cultural values and the moral values of effort and efficiency across time, we obtained metrices of several socio-cultural values, including individualism/collectivism, cultural tightness/looseness, and economic performance (i.e., per capita Gross Domestic Product, GDP).

Individualism/collectivism. We derived a text-based measure of year-by-year individualism and collectivism from the two countries based on the Google *Ngram* word frequency data, which provides insight into the prevalence of individualistic and collectivistic terms in published texts over time. The English and Chinese dictionaries are taken from existing studies in historical psychology (Greenfield, 2013; Zeng and Greenfield, 2015).

Tightness/looseness. Cultural tightness and looseness refer to the extent to which a culture adheres to social norms and tolerates deviant behavior (M. Gelfand, 2019; M. J. Gelfand et al., 2006; Jackson et al., 2019). Tight cultures have strict norms and little tolerance for deviations, whereas loose cultures are more permissive and flexible. Recent advances in research have facilitated the measurement of these constructs in textual content, examining the prevalence and context of norm-related words in various English corpora (Jackson et al., 2019). We translated the Chinese dictionary from the English version. A similar Google Ngram-based method as above was used.

We acknowledge that Google N-gram is only an imperfect reflection of the true cultural values of a society (Schmidt

et al., 2021). We compared the cultural values (individualism, collectivism, looseness, and tightness) based on Google N-gram and another, generically more balanced English corpus (i.e., Corpus of Historical American English, COHA) using ARIMA regression. During the period of history we studied, all the four cultural values based on these two corpora were highly correlated (see *Supplementary Methods* for detail; Supplementary Fig. 2). We decided to use Google N-gram here because, to the best of our knowledge, it is still the most accessible and comprehensive corpus in Chinese. Using Google N-gram as the source of the cultural variables makes the results of the two countries more comparable. More efforts are needed to create more stable and balanced corpora in Chinese and other non-English languages.

GDP per capita. To control economic factors that may influence the attitudes toward effort and efficiency, we utilized GDP per capita data. This information was obtained from the Maddison Project, a comprehensive dataset that provides historical GDP per capita estimates for various countries (Bolt and van Zanden, 2020). By including GDP per capita in our analysis, we aimed to account for potential economic influences on the evolution of the examined concepts.

Statistical analysis

Descriptive analysis. We first displayed the long-term trends in the moral values of effort and efficiency based on the U.S. Congressional speeches and *People's Daily*.

Null models as baseline. To establish reference points for linguistic fluctuations over time and demonstrate the moral significance of the concepts, we ran 10,000 simulations. In these simulations, we substituted effort- and efficiency-related words with randomly selected words and extracted their semantic similarities with moral evaluative words (virtue and vice dictionaries, respectively). It yielded a distribution of the association between 10,000 random sets of words (the same size as the effort and efficiency dictionaries, respectively) and the moral evaluative words for each year, forming a 95% confidence interval for these random associations. We then compared these with the moral associations with the concepts we are interested in (Bollen et al., 2021; Jones et al., 2020).

Bayesian change point detection. To assess the convergent validity of the moral measures, we employed Bayesian Change Point Detection, a statistical technique designed to identify shifts in data patterns by estimating the probability of change points at each timepoint. This approach allows us to pinpoint the precise time points at which moral value shifts occur and examine their correspondence with key historical turning points in each country. Utilizing this method, we can establish a connection between our findings and the broader historical context. The *bcp* package in R was used for change point analysis (Erdman and Emerson, 2008).

Time series. To estimate the long-term trends of moral values associated with effort and efficiency in the U.S. Congressional speeches and *People's Daily*, we applied the Autoregressive Integrated Moving Average (ARIMA) modeling, utilizing the *auto.arima* function from the forecast package in R (Hyndman and Khandakar, 2008), to the yearly association data. ARIMA is a time-series model that allows us to account for both the temporal dependencies and random fluctuations within the data, while controlling for GDP per capita.
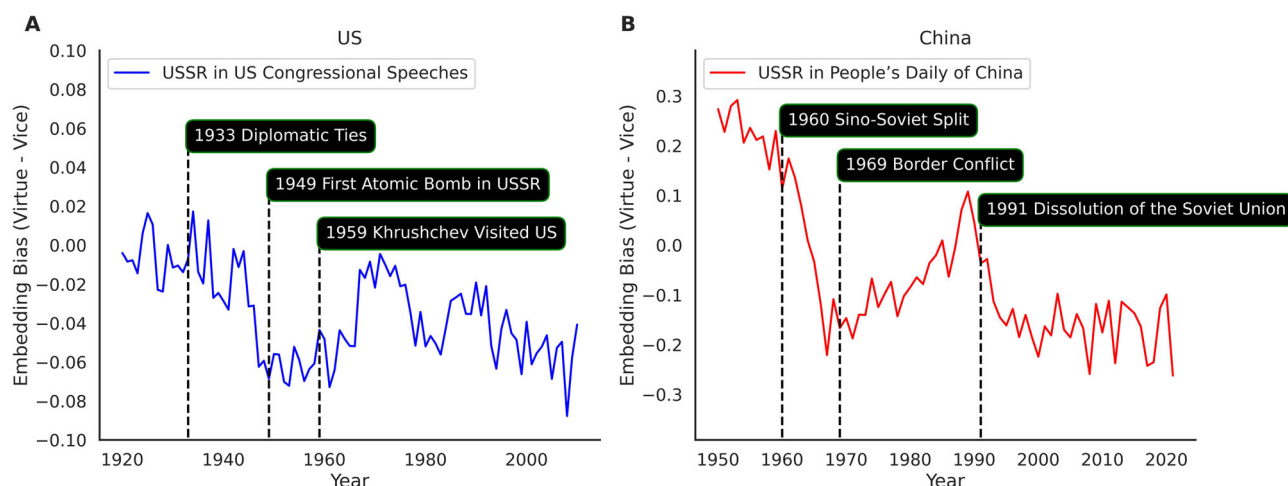
Fig. 1 Results of the dictionary validation analysis. Historical trends of moral attitudes toward the Union of Soviet Socialist Republics (U.S.S.R.) in (A) U.S. Congressional speeches from 1920 to 2011 and (B) People's Daily from 1950 to 2021. Historical events are marked with vertical dashed lines and annotated with black boxes.

Granger test. To further analyze the directionality between moral values and cultural changes, we employed Granger causality test to determine whether moral values of effort and efficiency precede cultural values, or vice versa. To ensure the stationarity of the data, we extracted the time series data from ARIMA models. To determine the optimal lag length for the Granger tests, we compared models with lags ranging up to 10 years and selected the one with the lowest Akaike Information Criterion (AIC). The Granger causality test was performed using the *grangertest* function from the *lmtest* package in R (Zeileis and Hothorn, 2002).

Results

Dictionary validation. To validate the moral measures in the U.S. Congressional speeches and *People's Daily*, we employed the embedding bias method to examine the moral values of the Union of Soviet Socialist Republics (U.S.S.R.) in the two corpora. It is expected that the evolution of moral attitudes toward the U.S.S.R. fluctuates in response to known events in the two countries diplomatic relationships with the U.S.S.R. As illustrated in Fig. 1A, the moral attitudes towards the U.S.S.R. in the U.S. Congressional speeches showed fluctuations in the 1920s and 1930s, with a prominent peak coinciding with the establishment of the U.S.-U.S.S.R. diplomatic ties in 1933, and remained relatively high during World War II, during which the U.S. and the U.S.S.R. were allies against Nazi Germany. However, the moral attitudes towards the U.S.S.R. quickly declined after the end of the war, when the tension between the Socialist Bloc and the West accelerated and the Cold War was in the corner. Of note, Winston Churchill's Iron Curtain Speech was delivered in 1946 and the Gouzenko Affair (a high-profile U.S.S.R. spy at the Soviet Embassy in Ottawa) went viral in the media between 1945 and 1946. Moving forward, the moral attitudes towards the U.S.S.R. remained negative in the Congressional speech corpus, despite a brief uptick coinciding with Khrushchev's 1959 visit to the U.S. The moral attitudes towards the U.S.S.R. in the *People's Daily* also notably fluctuated in response to historical events, as shown in Fig. 1B. For instance, there have been marked declines since the 1960s, during which the moral attitudes dropped from positive to negative. This downturn reached its lowest point in 1971 following the Sino-Soviet border conflict in 1969. However, there was a resurgence in moral attitude towards the U.S.S.R. in 1980s along with the resumption of diplomatic relations, culminating in

a peak when Soviet Communist leader Mikhail Gorbachev paid a state visit to China in 1989 for the Sino-Soviet Summit.

Historical trends of moral attitudes toward effort, efficiency, and inefficient effort. We first showed the descriptive trajectories of the evolution of moral attitudes toward efforts, efficiency, and inefficient effort over the last seven decades of Chinese history and nearly 14 decades of U.S. history, in their respective text corpus. Figures 2 and 3 display the historical evolutions of moral attitudes towards effort, efficiency, and inefficient effort. The results were based on the average of all moral foundations in the dictionary. Results based on each moral foundation are shown in Supplementary Fig. 3. All the years discussed below in this section were the first three highest probabilities determined by Bayesian Change Point Detection (see Supplementary Fig. 4 for the time series of posterior estimates) (Erdman and Emerson, 2008). This method was employed to detect substantial shifts in a data sequence, offering a probabilistic framework to identify the number and location of these changes by calculating the posterior probability of a change at each time point.

As displayed in Fig. 2A, in the U.S. Congressional speeches, the moral attitude towards effort is predominantly positive. An upward surge occurred in 1957 when it increased beyond the predictions of the null model, a year of substantial change identified by Bayesian Change Point Detection. During a period of mostly uprisings in the moral attitude towards effort from 1964 to 2010, there is a marked decline in 1998, coinciding with the Asian Financial Crisis. The trajectory of efficiency mirrors this historical pattern, with a less significant increasing trend starting from 1964. Between 1964 to 2010, 1996 stands out as a year that exhibits an abrupt dip in its moral values. Together, before the 1960s, effort and efficiency appeared relatively indistinguishable from each other and overlapped with the predictions of the null models. Post-1960s, a discernible moralization of these terms emerges, with effort consistently receiving relatively more positive evaluations than efficiency. The trajectory of moral attitude toward inefficient effort (Fig. 2B) is mainly positive but marked by fluctuations. Before the 1940s, the trajectory largely overlaps with the null model predictions. Since the 1940s, the trajectory has been consistently above the null model predictions.

An important feature of the U.S. Congress is its two-party system. Throughout history, the Republicans and the Democrats represent different social values and ideologies. A question thus arises - is the trajectory of moral attitudes we observed above
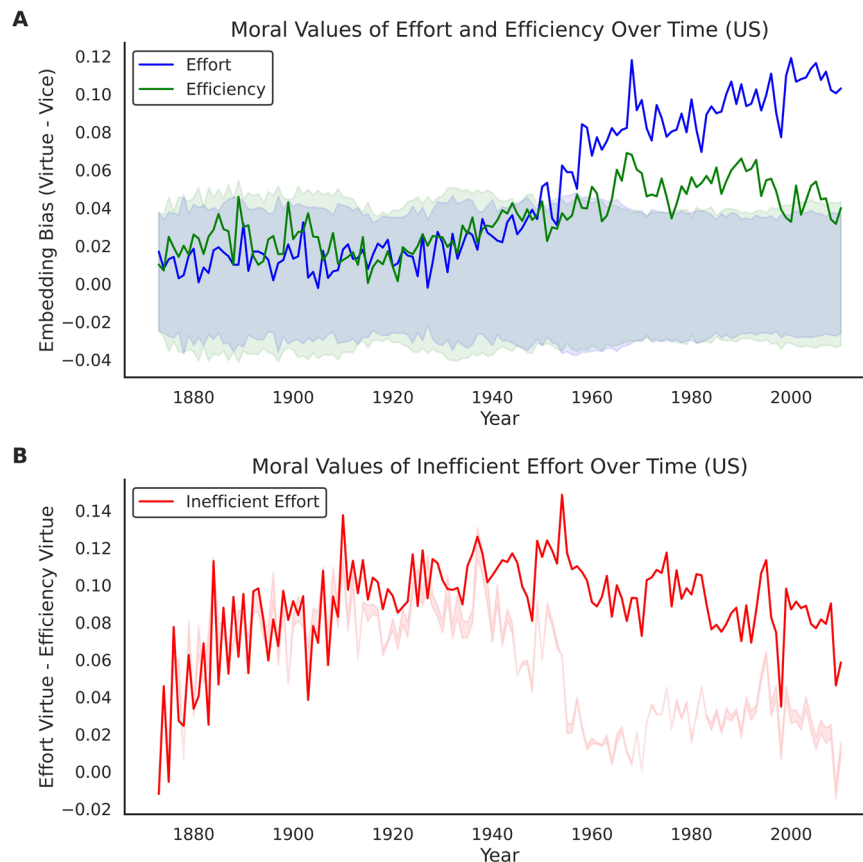
Fig. 2 Historical trends of moral attitudes towards effort, efficiency, and inefficient effort in the U.S. Congressional speeches (1873–2011). A Moral attitudes towards effort and efficiency. **B** Moral attitudes towards inefficient effort. The shaded regions denote the 95% confidence interval derived from a null model, comprising 10,000 sets of random words matched in length to the English effort/efficiency dictionaries (see the *Null Model as Baseline* section in *Methods*).

equally present in the narratives of both parties? To explore this, we trained new embedding models separately on the speeches of Democratic and Republican legislators. We then calculated the cosine similarity between the moral dictionary and the effort/ efficiency dictionaries as we did above (see *Supplementary Methods* for detail). The trajectories of moral attitudes towards effort, efficiency, and inefficient effort based on Democratic and Republican speeches are displayed in Supplementary Fig. 5. In essence, the trajectories based on the two parties largely overlap with each other throughout the years we studied. Correlation analysis (after removing temporal dependency using ARIMA) showed that the trajectories based on the two parties are strongly and positively correlated (effort: $r = 0.31$; efficiency: $r = 0.46$; inefficient effort: $r = 0.46$; all $ps < 0.001$). Moral attitudes towards effort and efficiency may also vary geographically at the state or even county level. Recent NLP-based work has begun to take into account finer-grained geographical variations in psychological outcomes (e.g., Atari and Henrich, 2023; Y. Chen et al., 2024; Lin et al., 2022). However, branching out to this question is beyond the scope of the present study. Since there is no equivalent partisanship in the Chinese corpus, we could not carry out a similar analysis there.

As shown in Fig. 3A, in *People's Daily*, effort consistently demonstrates a stronger association with virtue words compared to vice words. Notably, the trajectory of moral attitude toward effort is consistently above the levels predicted by the null model. Conversely, while efficiency maintains its positive valuation across most data points, it consistently falls within the 95% confidence intervals of the null model except for the duration

from the 1990s to 2000s, suggesting that the observed positive moral values is only distinguishable from mere random occurrences during this specific timeframe. This indicates that the moralization of efficiency may not be as distinct or robust as that of effort in this context. Importantly, in contrast to the U.S. Congressional speeches where both effort and efficiency underwent significant shifts in moral valuation across years, moral values of effort and efficiency in *People's Daily* are more stable, as evidenced by the absence of any year where the Bayesian Change Point (BCP) detection probability exceeded 50%. This highlights a distinctive pattern between the two cultural contexts.

Regarding inefficient effort shown in Fig. 3B, its association with positive moral values has been consistently positive over the seven decades that we have data for. The trend for inefficient effort remained relatively stable until 1959, the year marked as a substantial change point identified by Bayesian Change Point Detection method. Between 1959 and 1978, we observed some fluctuations but gradually a downward trend emerged after 1978, paralleling China's period of profound economic reform and transition to a more market-oriented economy, which emphasizes the importance of efficiency. The period from 1992 onward witnessed an even steeper decline in the positive moral attitudes towards inefficient effort, during which China's economic reform and opening moved to a "fast track." Notably, in 1992, the then paramount leader of the Chinese Communist Party, Deng Xiaoping, delivered a series of speeches that emphasized the importance of economic reform in the survival and thriving of the country and its people. In one of the speeches, he remarked that "whoever is against reform will be driven out of power," putting
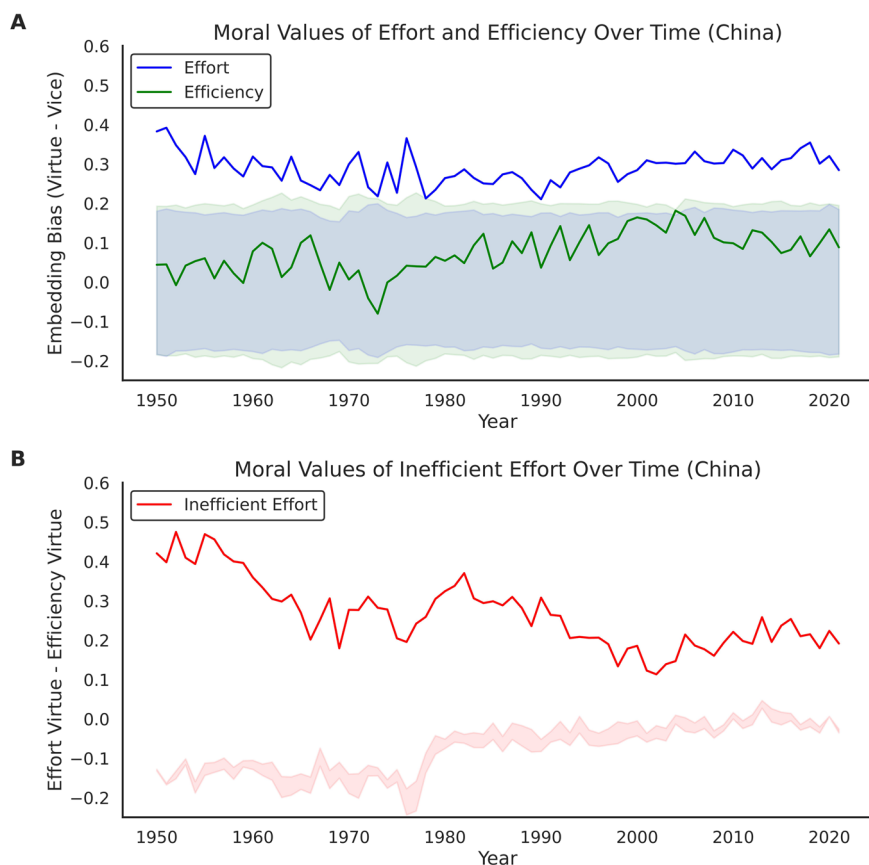
Fig. 3 Historical trends of moral attitudes towards effort, efficiency, and inefficient effort in *People's Daily* (1950–2021). A Moral attitudes towards effort and efficiency. **B** Moral attitudes towards inefficient effort. The shaded regions denote the 95% confidence interval derived from a null model, comprising 10,000 sets of random words matched in length to the Chinese effort/efficiency dictionaries (see the *Null Model as Baseline* section in *Methods*).

pressure on the government and party leadership to carry out economic reforms and marketization (Chatwin, 2024).

One might argue that the construct of effort is related to other constructs in social-personality and cultural psychology. For example, a recent cross-cultural work examined the "difficulty-as-improvement" mindset (seeing difficulties and hardship as opportunities for self-betterment) in several cultures (Yan et al., 2023). In particular, this work showed that the "difficulty-as-improvement" mindset was associated with the Protestant Work Ethics, which is also related to how people view effort and efficiency. To ascertain the relationship between the moral attitudes towards effort and difficulty-as-improvement mindset during the period of times covered by our Chinese and American corpora, we calculated the cosine similarity between the difficulty word list and the improvement word list reported in Yan et al. (2023) for all the years (Supplementary Fig. 6). We then fit ARIMA models to the two time series data separately and obtained the residuals for each year. This is to remove the autocorrelation and temporal dependency of each time series. To estimate the statistical association, we test the correlation between the residuals for each year between the moral attitude towards effort and the "difficulty-as-improvement" mindset. In the U.S. Congressional speech corpus, these two time series were not significantly related ($r = 0.092$, $p = 0.285$). In contrast, in the *People's Daily* corpus, these two time series were positively related ($r = 0.557$, $p < 0.001$). These results indicated that the relationship between the "difficulty-as-improvement" mindset and the moralization of effort is culturally dependent. Future research is needed to further delineate the modulatory role of specific cultural values in this relationship.

In a similar vein, another supplementary analysis showed that the moral attitudes towards effort and efficiency are largely

independent of the sentiments associated with these constructs in both the U.S. context and the Chinese context (except for the association between positive sentiment and moral attitudes towards effort in the Chinese corpus; for detail, see *Supplementary Methods* and Supplementary Fig. 7).

Some of the words in the effort and efficiency dictionaries are missing from some of the years we studied here (see Supplementary Tables 5 and 6 for the information of missing words from the U.S. and the Chinese corpora, respectively). We therefore pruned the dictionaries by removing the words that are absent from more than 50% of the time across the period we studied. The temporal evolution patterns of the moral attitudes towards effort, efficiency, and inefficient effort were nearly identical to the patterns we reported in Figs. 2 and 3 (Supplementary Fig. 8).

ARIMA models. Next, we used a time series analysis (ARIMA model) to examine the association between the fluctuations of the moral attitudes toward effort, efficiency, and inefficient effort on the one hand, and four cultural values (i.e., individualism, collectivism, cultural looseness, and cultural tightness) on the other hand. We computed the mean vector coordinates for seed words using pre-trained models, which are trained on Google News (Mikolov et al., 2013), Wikipedia (Bojanowski et al., 2017), and Twitter (Pennington et al., 2014) for English, and Renmin, Wikipedia and Weibo for Chinese (Li et al., 2018), to represent seed words in high-dimensional semantic spaces and identify similar terms. As shown in Table 1, during the period of U.S. history we examined here (1873–2011), positive moral attitude toward effort is positively correlated with Looseness ($b = 0.03$,

Table 1 ARIMA Results based on the U.S. Congressional speeches.

Predictor	(p, d, q)	Coef	SE	t	p	(p, d, q)	Coef	SE	t	p
Effort Model						*GDP-Adjusted Effort Model*				
Individualism	(0, 1, 1)	0.01	0.01	1.46	0.15	(0, 1, 1)	0.01	0.01	0.71	0.48
Collectivism	(0, 1, 1)	−0.01	0.01	−1.20	0.23	(0, 1, 1)	−0.00	0.01	−0.09	0.93
Looseness	**(0, 1, 1)**	**0.03**	**0.01**	**3.39**	**0.00**	**(1, 0, 1)**	**0.03**	**0.01**	**3.30**	**0.00**
Tightness	(0, 1, 1)	-0.00	0.01	−0.67	0.50	(0, 1, 1)	−0.00	0.01	-0.44	0.66
Efficiency Model						*GDP-Adjusted Efficiency Model*				
Individualism	(0, 1, 1)	−0.01	0.01	−1.30	0.20	**(1, 0, 1)**	**−0.01**	**0.01**	**−2.21**	**0.03**
Collectivism	**(1, 0, 1)**	**−0.01**	**0.00**	**−5.13**	**0.00**	(1, 0, 1)	−0.01	0.01	−1.65	0.10
Looseness	(0, 1, 1)	0.00	0.01	0.07	0.94	(1, 0, 1)	−0.00	0.01	−0.36	0.72
Tightness	(0, 1, 1)	−0.01	0.00	−1.06	0.29	(1, 0, 1)	−0.00	0.00	−0.91	0.36
Inefficient Effort Model						*GDP-Adjusted Inefficient Effort Model*				
Individualism	(3, 1, 1)	−0.00	0.01	−0.19	0.85	(3, 1, 1)	−0.01	0.01	−0.82	0.41
Collectivism	(3, 1, 1)	−0.01	0.01	−0.92	0.36	(3, 1, 1)	−0.00	0.02	−0.06	0.95
Looseness	(1, 1, 1)	−0.02	0.02	−0.97	0.33	**(0, 0, 0)**	**−0.06**	**0.01**	**−10.97**	**0.00**
Tightness	(3, 1, 1)	0.01	0.01	1.39	0.17	(3, 1, 1)	0.01	0.01	1.64	0.10

The ARIMA models on the left have one of the cultural variables as their predictor. The models on the right additionally included the log-transformed GDP per capita as a control variable. The ARIMA model parameters are specified by its nonseasonal components (p, d, q). "Coef": coefficient; SE: standard error.
Bolded statistics indicate statistical significance at p < 0.05 level.

Table 2 ARIMA Results based on People's Daily of China.

Predictor	(p, d, q)	Coef	SE	t	p	(p, d, q)	Coef	SE	t	p
Effort Model						*GDP-Adjusted Effort Model*				
Individualism	(0, 1, 1)	0.01	0.02	0.71	0.48	(0, 1, 1)	0.03	0.03	1.02	0.31
Collectivism	(0, 1, 1)	0.03	0.01	1.94	0.05	**(4, 1, 1)**	**0.04**	**0.01**	**3.71**	**0.00**
Looseness	(0, 1, 1)	−0.01	0.03	−0.23	0.82	(0, 1, 1)	−0.02	0.04	-0.47	0.64
Tightness	(0, 1, 1)	0.01	0.01	0.46	0.64	(0, 1, 1)	0.01	0.01	0.58	0.56
Efficiency Model						*GDP-Adjusted Efficiency Model*				
Individualism	(0, 1, 3)	−0.02	0.04	−0.43	0.66	(0, 0, 1)	−0.04	0.02	−1.75	0.08
Collectivism	(0, 1, 3)	−0.04	0.03	−1.32	0.19	(1, 0, 3)	−0.03	0.02	−1.40	0.16
Looseness	**(1, 0, 0)**	**0.03**	**0.01**	**4.64**	**0.00**	**(1, 0, 0)**	**0.05**	**0.03**	**2.06**	**0.04**
Tightness	(0, 1, 3)	−0.01	0.02	-0.51	0.61	(0, 0, 1)	0.02	0.01	1.87	0.06
Inefficient Effort Model						*GDP-Adjusted Inefficient Effort Model*				
Individualism	(0, 1, 1)	−0.03	0.04	−0.66	0.51	(1, 0, 1)	−0.06	0.06	−1.08	0.28
Collectivism	**(1, 0, 1)**	**0.06**	**0.02**	**2.84**	**0.00**	(1, 0, 1)	0.05	0.03	1.68	0.09
Looseness	(0, 1, 1)	−0.09	0.05	−1.68	0.09	**(1, 0, 1)**	**−0.15**	**0.04**	**−4.33**	**0.00**
Tightness	(0, 1, 1)	−0.02	0.02	−0.89	0.37	(1, 0, 1)	−0.03	0.02	−1.47	0.14

Bolded statistics indicate statistical significance at p < 0.05 level.

95% CI [0.01, 0.05], $p < 0.001$), even after controlling for GDP per capita ($b = 0.03$, 95% CI [0.01, 0.04], $p < 0.001$). This suggests that in the society with a higher tolerance of deviance (i.e., higher cultural looseness), we can expect a significant increase in the positive moral attitude towards effort.

For the moral attitude toward efficiency, collectivism is a significant predictor ($b = -0.01$, 95% CI [−0.02, −0.01], $p < 0.001$). However, the significant relationship disappeared after controlling for GDP per capita ($b = -0.01$, 95% CI [−0.03, 0.00], $p = 0.099$). This implies that as collectivist values decrease in U.S. society, the moral attitudes toward efficiency in the U.S. Congressional speeches increase, but this relationship appears to be dependent on the society's economic performance. In contrast, Individualism is not in itself a significant predictor of the moral attitude toward efficiency ($b = -0.01$, 95% CI [−0.03, 0.01], $p = 0.195$). Interestingly, however, when adjusted for GDP per capita, Individualism became a significantly negative predictor ($b = -0.01$, 95% CI [−0.03, −0.00], $p = 0.027$). This suggests that when the economic performance is held constant, the more prevalent the individualist values are in U.S. society, the more negative the moral attitude toward efficiency is, as observed in Congressional speeches.

For the moral attitude toward inefficient effort, after controlling for GDP per capita, Looseness became a negative predictor ($b = -0.06$, 95% CI [−0.07, −0.05], $p = < 0.001$). This suggests that in the relatively culturally looser periods in the U.S. history, inefficient effort in the U.S. congressional speeches becomes more morally negative statistically, possibly indicating a greater condemnation of wastefulness and inefficiency in their public discourse.

For *People's Daily* (1950–2021), the effort models show that collectivism was a significantly positive predictor of effort after controlling for GDP per capita ($b = 0.04$, 95% CI [0.02, 0.06], $p < 0.001$) (Table 2). The significant influences of collectivism on the moral attitudes towards effort reflect the intrinsic cultural appreciation for hard work and diligence that is deeply ingrained in Chinese culture (Heine, 2001; Leong et al., 2014).

In the basic efficiency models, Looseness emerged as a positive predictor of Efficiency before ($b = 0.03$, 95% CI [0.02, 0.05], $p < 0.001$) and after controlling for GDP per capita ($b = 0.05$, 95% CI [0.00, 0.10], $p = 0.040$). This association can be interpreted in light of the societal transformation, where flexible norms and behaviors (indicative of looseness) might lead to a favorable

valuation of efficiency during China's shift toward a market economy.

Most notably, in the inefficient effort models, Collectivism was a significantly positive predictor only before controlling for GDP per capita ($b = 0.06$, 95% CI [0.02, 0.10], $p = 0.005$). Interestingly, Looseness emerged as a negative predictor of Inefficient Effort only after adjusting for GDP per capita ($b = -0.15$, 95% CI $[-0.22, -0.08]$, $p = < 0.001$). The negative impact of Looseness on moralization of inefficient effort observed in the *People's Daily* echoes findings from the U.S. congressional speeches, suggesting a broader, cross-cultural trend. This pattern could imply that societies with more flexible norms and behaviors might value inefficiencies less and view them as counterproductive in rapidly changing environments.

Granger tests. Did cultural values lead to changes in the moral valuation of effort and efficiency, or did these moral values trigger shifts in cultural norms? To examine the existence and directionality of these relationships, we applied Granger analysis to the time series of cultural variables and moral attitudes.

Our findings, as shown in Table 3, revealed that within the U.S. Congressional speeches, Individualism significantly influenced Effort ($F(9, 220) = 3.05$, $p = 0.002$) and Efficiency ($F(9, 220) = 2.56$, $p = 0.008$), without significant reverse causality from Effort ($F(9, 220) = 1.28$, $p = 0.251$) or Efficiency ($F(9, 220) = 0.61$, $p = 0.785$) back to Individualism. Similarly, Collectivism significantly influenced Effort ($F(10, 214) = 2.89$, $p = 0.002$) and Efficiency ($F(10, 214) = 3.12$, $p = < 0.001$), without notable reverse causality from Effort ($F(10, 214) = 0.86$, $p = 0.571$) or Efficiency ($F(10, 214) = 1.00$, $p = 0.442$) to Collectivism. In contrast, Inefficient Effort was a significant precursor of shifts in cultural values including Individualism ($F(9, 220) = 1.93$, $p = 0.049$) and Collectivism ($F(10, 214) = 3.30$, $p = < 0.001$). Meanwhile, cultural norms such as Tightness and Looseness did not show a causal influence on Inefficient Effort. In contrast, Inefficient Effort significantly predicted changes in Tightness ($F(10, 214) = 2.45$, $p = 0.009$).

The interplay between cultural variables and moral attitudes toward effort and efficiency showed different patterns in *People's Daily*. Specifically, Individualism had a significant causal influence on Effort ($F(9, 82) = 2.07$, $p = 0.042$) with no significant reverse causality ($F(9, 82) = 1.19$, $p = 0.314$). Similarly, changes in Collectivism drove shifts in Effort ($F(9, 82) = 2.97$, $p = 0.004$) with no reverse relationship ($F(9, 82) = 0.82$, $p = 0.599$). Neither Looseness nor Tightness showed a significant causal influence on Effort. There was a significant impact of Effort on the change of

Tightness ($F(9, 82) = 2.01$, $p = 0.048$). This suggests that increased valuations of effort might have some influence on adherence to norms and regulations. None of the cultural variables demonstrated a significant causal influence on Efficiency. However, intriguingly, Efficiency had a significant causal influence on Individualism ($F(9, 82) = 2.33$, $p = 0.021$).

In analyzing Inefficient Effort, a robust causal relationship was identified where Collectivism showed a causal relationship with Inefficient Effort ($F(9, 82) = 2.94$, $p = 0.004$) and vice versa ($F(9, 82) = 2.37$, $p = 0.020$) in the Chinese narrative. This bidirectional causality indicates a dynamic interplay between collective values and the moralization of inefficient efforts. Additionally, Looseness preceded the changes of Inefficient Effort ($F(2, 124) = 3.73$, $p = 0.027$) with no significant reverse causality ($F(2, 124) = 1.76$, $p = 0.176$). Complemented by the ARIMA models, the results indicated that collectivism positively influenced the moral values associated with effort. Furthermore, there was a positive bidirectional relationship between collectivism and the moralization of inefficient effort (Table 3).

For robustness checks, we reran the ARIMA models and Granger tests with the pruned effort and efficiency dictionaries (i.e., removing words that are missing from more than 50% of the years we studied) (Supplementary Tables 7–10). We also reran the ARIMA models and Granger Tests for the U.S. corpus using cultural variables derived from COHA (Supplementary Tables 11 and 12). The results remained qualitatively consistent.

Discussion
In this study, we combined a computational linguistic approach (Atari and Dehghani, 2022; Caliskan et al., 2017; Garg et al., 2018; Hamilton et al., 2016; Kennedy et al., 2021a; Xu et al., 2021) and historical text corpora in China and the U.S. (Atari and Henrich, 2023; Muthukrishna et al., 2021) to examine the historical trend of the moral attitudes towards effort and efficiency (Celniker et al., 2023). The two societies exemplify two distinctive cultures: the Protestant Work Ethic (PWE) predominant in the U.S. (Furnham, 1984; Uhlmann and Sanchez-Burks, 2014), and Confucian values that characterize China (Hwang, 2012, 2015). By examining the historical trend of these moral attitudes in the U.S. and China, we offer insights into the evolving cultural narratives of hard work and productivity.

The U.S., deeply influenced by the PWE, has historically valued hard work as a moral virtue during the rise of capitalism. Yet, our study discerns a more intricate narrative. Up until the end of the 1940s, the moral attitudes toward effort and efficiency were indistinguishable, at least in the Congressional speech corpus,

Table 3 Granger Test Results based on the U.S. Congressional speeches corpus.

IV	DV	Lag	F value	p value	Reverse F	Reverse p
Individualism	Effort	9	**$F(9, 220) = 3.05$**	**0.00**	$F(9, 220) = 1.28$	0.25
Collectivism	Effort	10	**$F(10, 214) = 2.89$**	**0.00**	$F(10, 214) = 0.86$	0.57
Looseness	Effort	4	$F(4, 250) = 1.59$	0.18	$F(4, 250) = 1.8$	0.13
Tightness	Effort	10	$F(10, 214) = 1.57$	0.12	$F(10, 214) = 1.26$	0.25
Individualism	Efficiency	9	**$F(9, 220) = 2.56$**	**0.01**	$F(9, 220) = 0.61$	0.78
Collectivism	Efficiency	10	**$F(10, 214) = 3.12$**	**0.00**	$F(10, 214) = 1$	0.44
Looseness	Efficiency	3	$F(3, 256) = 2.49$	0.06	$F(3, 256) = 2.64$	>0.05
Tightness	Efficiency	9	$F(9, 220) = 1.78$	0.07	$F(9, 220) = 1.11$	0.36
Individualism	Inefficient Effort	9	$F(9, 220) = 0.97$	0.47	**$F(9, 220) = 1.93$**	**0.05**
Collectivism	Inefficient Effort	10	$F(10, 214) = 0.70$	0.72	**$F(10, 214) = 3.3$**	**0.00**
Looseness	Inefficient Effort	10	$F(10, 214) = 1.48$	0.15	$F(10, 214) = 1.61$	0.11
Tightness	Inefficient Effort	10	$F(10, 214) = 0.93$	0.51	**$F(10, 214) = 2.45$**	**0.01**

The columns labeled "Reverse F" and "Reverse p" represent the F-statistic and p-value from the reverse Granger test, where the dependent variable (DV) is swapped with the predictor. As an illustration, the first row demonstrates that at a lag of 9, Individualism is a Granger cause of changes in Effort ($p = 0.002$). Conversely, Effort is not a Granger cause for changes in Individualism ($p = 0.251$). Same for Table 4.
Bolded statistics indicate statistical significance at $p < 0.05$ level.

Table 4 Granger Causality Results based on _People's Daily_ corpus.

IV	DV	Lag	F value	p value	Reverse F	Reverse p
Individualism	Effort	9	**F(9, 82) = 2.07**	**0.04**	F(9, 82) = 1.19	0.31
Collectivism	Effort	9	**F(9, 82) = 2.97**	**0.00**	F(9, 82) = 0.82	0.60
Looseness	Effort	9	F(9, 82) = 1.07	0.40	F(9, 82) = 1.08	0.38
Tightness	Effort	9	F(9, 82) = 1.09	0.38	**F(9, 82) = 2.01**	**0.05**
Individualism	Efficiency	9	F(9, 82) = 0.46	0.89	**F(9, 82) = 2.33**	**0.02**
Collectivism	Efficiency	9	F(9, 82) = 1.13	0.35	F(9, 82) = 0.52	0.86
Looseness	Efficiency	10	F(10, 76) = 0.74	0.68	F(10, 76) = 0.4	0.94
Tightness	Efficiency	9	F(9, 82) = 1.26	0.27	F(9, 82) = 0.98	0.46
Individualism	Inefficient Effort	9	F(9, 82) = 1.05	0.41	F(9, 82) = 0.82	0.60
Collectivism	Inefficient Effort	9	**F(9, 82) = 2.94**	**0.00**	**F(9, 82) = 2.37**	**0.02**
Looseness	Inefficient Effort	2	**F(2, 124) = 3.73**	**0.03**	F(2, 124) = 1.76	0.18
Tightness	Inefficient Effort	10	F(10, 76) = 1.23	0.29	F(10, 76) = 1.92	0.06

Bolded statistics indicate significance at $p < 0.05$ level.

often overlapping with null models. However, marked increases in the positive moral values of effort and efficiency emerged starting from the 1950s and continued into the 1960s and 1970s, with effort surpassing efficiency in moral values. Intriguingly, during this period, the moral attitude toward inefficient effort starts to increase. This trend coincides with America's post-World War II economic boom, material prosperity, and optimism and confidence. Directly relevant to the Congressional speech corpus we used, during this time, the Congress established the Council of Economic Advisors to encourage high employment, substantial profits, and low inflation. Within this context, pure effort, even if not always immediately efficient or productive, gained increasingly positive moral values. Future work is needed to ascertain the relationships between these different political and economic trends (zeitgeist) on the one hand, and the society's moral attitudes towards efforts and efficiency on the other.

As for China, our findings depict a narrative that is different from that of the American one. The moral value of effort remains consistently positive and above the confidence interval of the null model throughout our period of observation. In contrast, the moral value of efficiency is mostly within the confidence interval of the null model, indicating that the concept of efficiency is not consistently and meaningfully associated with morality during this period of history. The lack of moral value associated with efficiency may be related to China's long-standing adherence to Confucian values, which emphasize collective obligations irrespective of their outcomes. This philosophy is captured by sayings such as "Heroes are not judged solely by success or failure." Indeed, Confucius himself is proud of being someone who "knows the impracticable nature of the times and yet will be doing in them" (_Analects_). A significant decline of positive moral attitude toward inefficient effort began at the turn of the 1960s, when China's leadership became aware of the detrimental effects of unrealistic ideological zeal and rolled back some of the inefficient policies mandated during the Great Leap Forward. Another decline occurred in the early 1990s and coincided with the implementation of market reform policies. The zeitgeist of this period is best illustrated by the motto of the City of Shenzhen, one of the pioneering regions of China's economic reform, "Time is money, efficiency is life." This trajectory, perhaps, mirrors China's transition to a rapidly modernizing and industrializing country.

The findings from our time series analysis reveal intriguing cultural insights. Both in the U.S. and in China, a consistent negative relationship was observed between cultural looseness and the moral attitudes toward inefficient effort. This suggests that when a society is less culturally loose, it will place more moral value on effort relative to efficiency. Another commonality

emerging from the Granger tests is that it was individualism and collectivism, rather than cultural tightness or looseness, that preceded shifts in the moral values of effort. This indicates that while loosening cultural norms might influence attitudes toward work efficiency, the driving factors behind moral values of effort are rooted more in the individualistic or collectivistic tendencies of these societies.

Our results from the exploratory time series analysis (ARIMA and Granger tests), reveal distinct patterns of associations and precedence between cultural variables (i.e., individualism, collectivism, cultural tightness/looseness) and the moral attitudes towards effort and efficiency (i.e., effort, efficiency, and inefficiency effort) in the U.S. and China. Specifically, in the U.S., cultural looseness is positively correlated with moral values of effort and negatively with moral values of inefficient effort. Additionally, individualism is negatively correlated with moral values of efficiency. This suggests that in U.S. society, where cultural looseness prevails, there may be a greater emphasis on productive effort. Meanwhile, the change of individualism could be associated with the devaluation of efficiency. On the other hand, in China, collectivism upholds the moral importance of effort, even when its outcomes appear insignificant. This is evident from the positive and bidirectional relationship between collectivism and the moralization of inefficient effort. However, cultural looseness is negatively associated with and precedes positive moral value of inefficient effort, independent of the society's economic performance. This might reflect Confucian values that emphasize individuals' obligations to the group and social ideal, valuing effort to fulfill these obligations, regardless of its outcomes, is challenged by the shifting dynamics brought about by cultural looseness.

Furthermore, the results combining ARIMA models and Granger tests highlight distinct cultural dynamics in the U.S. and China. Cultural looseness is mainly positively associated with the moral values of effort in the U.S., while mainly positively correlated with moral values of efficiency in China, although no causal significance was detected in these relationships. Notably, both countries displayed a negative correlation between cultural looseness and the moral values of inefficient effort. Another distinct pattern emerged when examining collectivism. While in the US, collectivism showed a negative unidirectional influence on the moral value of efficiency, in China, collectivism had a positive driving impact on the moral values of effort and inefficient effort. This suggests different mechanisms may explain how cultural looseness and collectivism shape work ethics across the two cultures.

These findings not only underscore the intricate relationships between cultural dimensions and moral values but also highlight

the divergent paths through which these associations manifest in different socio-cultural contexts. However, we acknowledge that our time series analyses are largely exploratory and descriptive. For the Granger tests, we noted that the analysis of mutual influence between cultural variables and moral attitudes without examining other complex external variables (such as politics, economics) is limited in revealing the mechanisms that underlie those changes in these variables. Future research is needed to more closely address the mechanisms underlying the relationship between societal and cultural variables and moral attitudes towards effort and efficiency.

One may notice that in some of the ARIMA models, individualism and collectivism have the same direction of an effect. While it is true that individualism and collectivism sometimes exhibit similar trends in the ARIMA analyses, there are no significant same-direction effects for any given analysis. It is not unexpected that these two cultural values sometimes may have similar effects on moral attitudes towards effort and efficiency. Our dictionaries of effort concept and efficiency concept do not specify the beneficiary of the effort or efficiency. In that sense, our analysis was agnostic of goals of effort or efficiency. For example, an effortful and/or efficient endeavor could be exerted to obtain collectivist goals (e.g., as a slogan during the "Great Leap Forward" movement in China goes, "Work hard, strive for the upper reaches, and build socialism as quickly, efficiently, and economically as possible") or individualist goals (e.g., as exemplified by meritocracy narratives, "The American Dream I believe in is one that provides anyone willing to work hard enough with the opportunity to succeed" - U.S. Senator Tammy Duckworth). In sum, it is conceivable that individualism and collectivism values correlate with moral attitudes towards effort/efficiency in the same direction.

There are several limitations in the present research. First, our text corpora are exclusively drawn from U.S. Congressional speeches and Chinese newspapers. Both sources are formal, politically oriented narratives and texts. While these texts offer rich insights into their respective societies and times, future investigations should also diversify the source materials to include non-political content such as literature, local newspapers, magazines, and other popular media outlets, to capture a more comprehensive and representative understanding of work ethics. More broadly, before the widespread use of the internet and social media, a society's written records (e.g., books, newspapers, magazines) were generally produced (and consumed) by political, economic, and/or cultural elites (Muthukrishna et al., 2021). Even the texts from more accessible online social media of our time do not reflect the entire society's (offline) view faithfully (Robertson et al., 2024). This is a common challenge that most text-based historical psychology research faces and one should keep this in mind when conducting and interpreting such research.

Another limitation is the restricted time frame of our study. Although this period witnessed momentous societal shifts in both the U.S. and China, a deeper historical dive would no doubt unravel even richer evolutionary patterns. In the West, epochs such as the Renaissance, Age of Exploration, Reformation—which heralded the rise of the PWE—and the Industrial Revolution, and Age of Enlightenment likely have enormous influences on the moral values of effort and efficiency. Likewise, China's transition from millennia of imperial rule to the republic regime at the turn of the 20th century, the New Culture Movement, World War II, and the Chinese Civil War, may have profoundly shaped the moral landscapes of effort and efficiency. Future research is needed to examine the evolution of moral attitudes towards effort and efficiency during these historical times.

Lastly, our moral evaluative words were based on the Moral Foundations Dictionary (MFD). This dictionary, while grounded in the Moral Foundations Theory (MFT) (Graham et al., 2013),

only represents one of various computational linguistic measures of morality, such as the moral judgment dictionary from The Development and Psychometric Properties (Boyd et al., 2022; Brady et al., 2020) or other versions of the Moral Foundations Dictionary (Hopp et al., 2020). For example, the Extended Moral Foundations Dictionary (eMFD) was based on a more comprehensive, crowd-sourced annotation procedure instead of expert-driven content analysis (Hopp et al., 2020, 2021; Weber et al., 2021, p. 201). The present study does not aim to advocate one theoretical framework or tool over another but utilizes the MFD for its established efficacy in analyzing both English and Chinese texts. It is also worth noting that the field of computational linguistics has been burgeoning, with novel tools being developed for moral content analysis in textual data (Hoover et al., 2018; Vaisey and Miles, 2014). Future studies that integrate and compare these advanced tools will be able to bring about a richer, more nuanced exploration of morality from textual data.

Our language-based historical psychology approach to understanding moral attitudes towards effort and efficiency adds a cross-cultural and historical dimension to recent work on the perception and evaluation of work and effort (Graeber, 2018; Steger et al., 2013; Ward, 2024). Inefficient effort is work done for the sake of it being done instead of some useful products or outcomes, and therefore is an essential part of meaningless work. Our research provides insights that the moral outlooks of meaningful or meaningless work varies across cultures and times. Critically, in our own time, we are witnessing perhaps one of the most important revolutions in human history: with the rapid growth of artificial intelligence in various domains of work and life, the necessity and meaning of human work in its traditional sense is inevitably facing fundamental challenges. What are the unique roles of human effort and agency in future work? How will people's moral attitudes towards effort and efficiency change when more human efforts can be replaced and improved by AI-powered automation? Future research is needed to ascertain these theoretically and practically important questions.

In sum, we investigated the evolving patterns of moral attitudes toward effort, efficiency, and inefficient effort in the recent history of China and the U.S., by combining an effective computational linguistic tool and historical text corpora. We found that the fluctuations of moral attitudes towards inefficient effort roughly corresponded to critical historical events or periods in both societies that mark significant social changes in world view and ideology. Further investigation through time series analysis suggests associations and possible influences of social and cultural factors, such as collectivism/individualism and cultural looseness, on the evolution of moral attitudes toward inefficient effort. Our study not only provides insights into the historical and sociocultural origins of the moralization of inefficient effort but also has implications for historical psychological investigations into the evolution of morality.

Data availability

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Acknowledgements

Author contributions
A.X.C. and H.Y. designed the study, A.X.C. did the analyses, A.X.C, S.S., and H.Y. wrote the initial and revised manuscript.

Competing interests
The authors declare no competing interests.

Ethical approval
Ethical approval was not required as the study did not involve human participants. Since there were no human participants involved in this study, the last author's institution (University of California Santa Barbara) judged that this research did not need to complete a protocol with the Office of Research Application for the use of Human Subjects.

Informed consent
This article does not contain any studies with human participants performed by any of the authors. Therefore, an informed consent is not relevant.

Additional information