

Article

An Alternative Globalization Barometer for Investigating the Trend of Globalization

Sha Sun ¹, Haiyue Xu ², Minsong He ³, Yao Xiao ¹ and Huayong Niu ^{1,*}¹ International Business School, Beijing Foreign Studies University, Beijing 100089, China² School of Russian Language, Beijing Foreign Studies University, Beijing 100089, China³ Faculty of Languages and Literatures, Ludwig Maximilian University of Munich, 80539 Munich, Germany

* Correspondence: niuhuayong@bfsu.edu.cn; Tel.: +86-10-8881-6347

Abstract: Analyzing, evaluating, and predicting the trend of globalization are highly valuable endeavors. However, existing literature lacks a quantifiable metric for objective evaluation. To fill the gap, we first compiled a Globalization Index based on existing globalization indices and using the CRITIC weighting method. Second, we constructed the Globalization Barometer and a trend term for trend analysis using the HP filtering method. Third, we conducted time-series predictions for globalization trajectory by applying the Random Forest model. Our results indicate that: (1) The *de facto* and *de jure* globalization both displayed a gradually upward trend over time; (2) the 2008 financial crisis and the 2020 COVID-19 pandemic negatively impacted globalization and served as turning points; (3) on a positive note, COVID-19 has narrowed the gap in both *de facto* and *de jure* globalization. This is due to the fact that the shocks were uneven, with economies that participated more in globalization weathering the brunt of the impact, while economies that participated less experiencing little changes; (4) the *de facto* and *de jure* globalization are predicted to remain on an upward trend for the subsequent 5 years. This research provides essential references for assessing and predicting globalization trends.



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1. Introduction

Globalization is an impactful force for countries and regions all over the world. The trend of globalization influences multiple stakeholders, not least of which include actors in the economic, social, and even political fields. Most stakeholders need to base and readjust their strategies on how globalization will proceed.

Despite its importance, there is no consensus on assessing the trend of globalization in the existing literature. Some scholars believe that globalization is irreversible and it will continue to move forward. They argue that the globalization variables are more resilient than most people expected [1]. The increasing mobility of people, information, and technology worldwide has reduced the possibility of deglobalization [2]. Among them, positive globalization trends are especially reflected in increasing global exchanges of services and data [3]. Moreover, based on the fact that the world remains highly collaborative during the coronavirus outbreak, globalization will not end as a result of the pandemic [4]. Some foresee a slowdown in globalization in the near and long-term future, characterized by the concept of “slowbalization” [5]. These ideas predate the COVID-19 outbreak, such as the likely deceleration of globalization suggested by Bordo [6]. However, slowbalization is not a uniform trend. It includes a recession in economic globalization and a boom in information globalization [7]. Others hold the view that globalization is suffering a downturn. The current deglobalization is partially triggered by the pandemic exposing the underlying fragility in globalization [8,9]. This crisis has spurred the pre-pandemic

globalization skeptics [10], with economic and social factors further accelerating this skepticism worldwide [11]. Scholars conclude that, due to various anti-globalization factors, including inter-country inequalities, populism, protectionism, and unilateralism, a greater globalization process is difficult to achieve in the current world economy [12]. Populism, in particular, is heavily impactful. It threatens not only economic but also social and political globalization [13,14]. This rise of populism is fueled by the backlash against neoliberal constitutionalism [15]. Some scholars have refrained from defining a fixed standpoint, as it remains uncertain whether the crisis triggered by the COVID-19 pandemic marks the end of globalization [16]. However, they have pointed out crucial factors that may influence future trends. Digitalization, for instance, projects both centrifugal and centripetal forces on globalization [17], while the pandemic has transformative effects that paint a new image of a post-Covid era global market [18]. While recent studies have made important progress in evaluating and projecting how connections in the world will develop moving forward, they are mainly qualitative studies and therefore by nature, are prone to subjective judgements.

Another related strand of literature is the study of globalization indices. Traditionally, sociologists, economists, and others worked on different dimensions of globalization [19]. However, globalization by definition is a multifaceted concept that includes economic, social, and political aspects [20]. Therefore, to measure globalization in a more comprehensive way, most of the existing globalization indices have adopted an interdisciplinary approach, i.e., a composite index of globalization. The A.T. Kearney/Foreign Policy Globalization Index [21] was the first systematic measure of globalization, which measured and ranked 62 countries worldwide on four dimensions: Economic integration, personal contact, technological connectivity, and political engagement. Noteworthy indices include: The KOF Globalization Index [22] uses 43 indicators in the economic, social, and political dimensions and covers data pooled from 203 economies between 1970 and 2018. The CSGR Globalization Index [23] applies 16 indicators along the economic, social, and political dimensions, covering data from 119 countries and regions from 1982 to 2004. The Maastricht Globalization Index [24] measures the level of globalization in 117 countries in 2002, 2008, and 2012 presenting five dimensions: Political, economic, social and cultural, technological, and environmental. The DHL Global Connectedness Index [1] measures the depth and breadth of global connectivity of 140 economies between 2005 and 2020, using 12 indicators along four dimensions: Trade, capital, information, and people. The prior research showed its merits in providing the basic quantitative framework and methodology for constructing a globalization index. However, their scope is rather limited to presenting globalization in the past and present rather than trend analysis and forecasting.

In this case, an approach which quantifies the trend of globalization will be useful to provide forward-looking analyses, especially given that it is the changes of globalization than globalization per se that fulfills the greatest need. Current literature in economics and other fields used barometers to assess the trend of specific variables [25,26]. A barometer is a composite indicator designed for assessing the trend of growth and discovering turning points [25,26]. This implies that the construction of a barometer would serve as a suitable way to quantify globalization trends, which is rarely covered in the existing literature. The barometer can deliver fact-based, future-oriented solutions for industrial activities, provide theoretical instruments for academic purposes, and serve as a window for the public to monitor the current state of global interconnectedness.

In this paper, we constructed the Globalization Barometer and provided a trend analysis of globalization. Our research pooled data from 142 economies from 2000 to 2020, spanning economic, social, and political dimensions. The CRITIC method was used to assign indicator weights. The HP filter was used to implement the trend analysis. Finally, the Random Forest model was used to conduct time-series predictions for globalization trajectory.

The rest of the article is organized as follows. Section 2 illustrates the data and methods. Section 3 presents the results. Sections 4 and 5 are intended for discussion and conclusion.

2. Materials and Methods

2.1. Methodology Procedures

As presented in Figure 1, the assessment and prediction of globalization trend involve three steps:

- (1) The compilation of the Globalization Index. Initially, we compiled our globalization indicator framework by making revisions and amendments to existing globalization indices. Accordingly, relevant data were collected, imputed and normalized. Then, we used the CRITIC method to assign weights and aggregated the indicators to the globalization index.
- (2) The construction of the Globalization Barometer. We applied the HP filtering method to decompose the globalization index into two parts: The trend term and the deviation term, of which the latter is used to construct the Globalization Barometer.
- (3) Time-series prediction of globalization trajectory. The Random Forest model is used to predict the subsequent periods of globalization level.

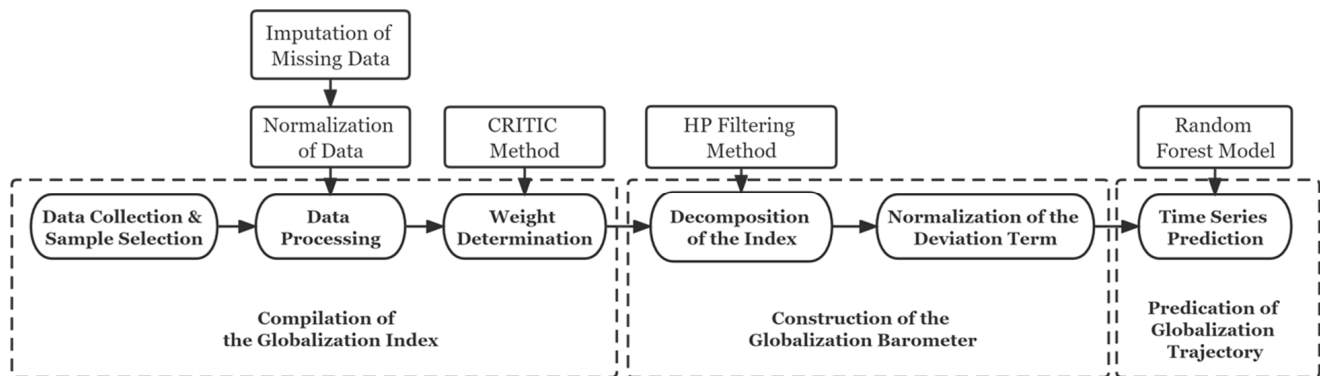


Figure 1. Methodology procedures.

2.2. Compilation Framework of the Globalization Index

A clear and universally recognized definition of globalization is necessary for compiling a globalization index. Based on emblematic articles in the field of globalization, including Sklair [27,28], Stoudmann and Al-Rodhan [29], and Scholte [30], globalization is defined as the global increase in connection, interdependence, and convergence of all economies in the economic, social, and political fields. In this work, we define globalization in three sub-dimensions: Economic globalization is reflected in the cross-border flows of products and services and the allocation of production factors on a global scale. Social globalization covers the migration of people and the transmission of information, accompanied by the convergence of cultures and exchanges in science and technology. Political globalization denotes intergovernmental cooperation and collaboration within the framework of international organizations.

Existing globalization indices have provided an adequate structure to quantify the level of globalization. Following Gygli et al. [22], we introduce two dimensions, namely, *de facto* and *de jure* globalization. *De facto* globalization refers to the extent to which a country's participation in globalization has been achieved, while *de jure* globalization is defined as the decisions, policies, institutions, and other proactive factors that the country has put in place to make its participation in globalization more possible.

Based on prior indices, our index also made several adjustments and improvements as described below.

- (1) We measured political globalization more broadly. As an expansion of existing indices [22–24], the political dimension is determined by two sub-dimensions: International cooperation and global governance. International cooperation measures the degree of intergovernmental coordination and communication, while global gov-

ernance evaluates the participation level of each government in the framework of international organizations. Of note, this paper differs from existing indices in the identification of international organizations. Existing indices mostly use all inter-governmental organizations (IGOs) and non-governmental organizations (NGOs). This approach assumes that all IGOs and NGOs contribute equally to the process of globalization, neglecting the individual difference in capacity. In our context, the international organization mainly refers to the UN and its affiliated institutions, since we propose that UN plays a crucial role in the formation of modern globalization and thus should lay emphasis on its work.

- (2) We measured social globalization more impartially. Indicators, such as McDonald's restaurants and IKEA stores, have long been criticized for measuring Americanization or Westernization rather than cultural globalization, as pointed out in the founding paper of the KOF index [22]. Accordingly, we removed these indicators and used trade in printed goods and international trademarks instead to evaluate *de facto* cultural globalization.

Another adjustment reflects in the inclusion of decentralized indicators. Some new indicators, such as the language popularity index, are added to our index system. Rather than measuring the average proficiency of English in a given country, the language popularity index measures the number of foreign nationals speaking the majority language of that country (the most spoken language among all official languages of that country) as a percentage of those speaking that language worldwide. Language functions as the medium of culture [31], opens more possibilities for cultural transmission and exchange, and thus could be included in cultural globalization. Additionally, the social tolerance index, which refers to the extent of recognition and acceptance of differences, and willingness to grant equal rights [32], was included to address the importance of mutual respect and appreciation of different cultures.

- (3) In addition to the adjustments in the indicators, there are some amendments to the measurements. Previous studies have shown that absolute indicators are prone to the impact of scale [22]. Therefore, the indicators chosen in this paper are mostly relative indicators. This method ensures all components are statistically comparable.

In conclusion, this paper constructed a *de facto* and *de jure* globalization index system consisting of three primary, eight secondary, and twenty-eight tertiary indicators as demonstrated in Table 1. See Table A1 in Appendix A for measurement of all indicators.

Table 1. The globalization index: Variables description.

Primary Indicators	Secondary Indicators	Tertiary Indicators	Source
Economic	Trade	<i>de facto</i>	Trade in products Trade in services
			World Bank WDI World Bank WDI
		<i>de jure</i>	Tariffs Trade agreements
			World Bank WDI DESTA
	Financial	<i>de facto</i>	Foreign direct investment Portfolio investment International income payments
			IMF IIP IMF IIP IMF BoP
		<i>de jure</i>	Capital account openness International investment agreements
			Knoema Investment Policy Hub

Table 1. Cont.

Primary Indicators	Secondary Indicators		Tertiary Indicators	Source
Social	Informational	<i>de facto</i>	Used internet bandwidth	ITU ICT-Eye
		<i>de jure</i>	Internet access	ITU ICT-Eye
	Interpersonal	<i>de facto</i>	International tourism International students Migration	World Bank WDI World Bank WDI World Bank WDI
		<i>de jure</i>	Freedom to visit International airports	DEMIG VISA CIA World Factbook *
	Technological	<i>de facto</i>	International patents High technology exports	World Bank WDI World Bank WDI
		<i>de jure</i>	Global innovation index	GII
	Cultural	<i>de facto</i>	Trade in printed goods International trademarks	UN Comtrade WIPO IP Portal
		<i>de jure</i>	Social tolerance index Language popularity index	World Value Survey Ethnologue *
Political	International Cooperation	<i>de facto</i>	Foreign affairs agencies	Lowy Global Diplomacy
		<i>de jure</i>	International organizations International treaties	CIA World Factbook * UN Treaty Collection *
	Global governance	<i>de facto</i> <i>de jure</i>	Speech contribution in UN UN peacekeeping contribution	UN Digital Library * UN Peacekeeping *

* Indicators manually collected and calibrated from accessible databases.

2.3. Data

2.3.1. Data Collection and Sample Selection

In this work, we covered diverse data from the economic, social, and political fields. Our primary sources of data are obtained from databases of the UN, the World Bank, and the IMF. In addition, our work collected data from trustworthy sources, such as the CIA, the World Value Survey, and Ethnologue. In total, all 19 different databases were consulted (Table 1).

The raw dataset covers 217 economies with 28 variables (indicators) over the timespan (year 2000 to 2020). However, it suffers from a severe missing observation problem, which calls for sample selection. We decide whether to retain a sample following two principles: (1) Data coverage ratio should be improved; (2) the structure of the sample should be in proportion to the raw dataset from a geographic and economic perspective. With careful consideration, we narrowed our sample to 142 economies. See Table A2 in Appendix A for the structure of the sample compared with the raw dataset.

2.3.2. Data Processing

Data processing involves imputation of missing data and data normalization. Following the practice of existing globalization indices [22–24], we imputed the missing data within a series using linear interpolation and extrapolation. In addition, the values of the indicators themselves are not comparable due to differences in the scale and units of the indicators. Therefore, we normalized the data using the max-min method.

2.4. Methods

2.4.1. The CRITIC Method

Two major weighting systems are used in related studies: The objective and subjective weighting methods [33]. The former is dataset-driven, while the latter is expert-driven. In order to eliminate subjective biases, our work employs the CRITIC method to aggregate

our indicators. This method is based on evaluating the comparative strength between indicators and the deviation of indicators to determine the weights of indicators.

Consider a normalized dataset represented by matrix M :

$$M = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

where m denotes the number of observations, and n denotes the number of indicators under the same category.

While determining the weights of a specific indicator, both standard deviation and its correlation between indicators are considered. In this regard, the weights are obtained as follows:

$$w_j = \frac{C_j}{\sum_{j=1}^n C_j} \quad (2)$$

where C_j denotes the quantity of information j -th indicator contains, which is determined as:

$$C_j = \sigma_j \cdot \sum_{k=1}^n (1 - r_{kj}) \quad (3)$$

where σ_j represents the standard deviation, and r_{kj} represents the correlation coefficient between indicator k and j .

2.4.2. HP Filter

Inspired by the Global Trade Barometer issued by World Trade Organization (WTO) [28], our work uses the Hodrick-Prescott (HP) filter method to formulate the Globalization Barometer. The HP filter, first proposed by Hodrick and Prescott [34], is a commonly used data-smoothing tool in macroeconomics. We use the HP filter method to decompose a series into trend and cyclical components. The original series can be represented as the following function:

$$y_t = \tau_t + c_t \quad (4)$$

where y_t is the original series, τ_t is the trend component for the long-term path, and c_t is the cyclical component which denotes short-run dynamics. The deviation is the actual level of output from the long-term trend. Therefore, the HP filter is defined as the following optimization function:

$$\min_{\{\tau_t\}} \left\{ \sum_{t=1}^T (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2 \right\} \quad (5)$$

where the first term is interpreted as the sum of the squared differences between actual globalization and trend, and the second term is a second-order difference equation that exists for the trend multiplied by the smoothing parameter λ . This parameter will determine the amount of volatility associated with a trend, namely, the higher λ that is used, the smaller the volatility will be. Following Backus and Kehoe [35], the value of the smoothing parameter λ is assigned to a value of 100 for annual data in this paper.

2.4.3. Random Forest Model

Machine learning is the learning process of analyzing data automatically to obtain a model from the data and using the model to make predictions about unknown data. Random Forest is an integrated algorithm that reduces the variance of a model by combining multiple decision trees, correcting the habit of a single decision tree to over-fit its training set. Among various machine learning algorithms, Random Forest generally has

better generalization performance [36]. It is resilient to outliers in the dataset and does not require considerable parameter-tuning. In 2001, Breiman [37,38] improved the Random Forest model, which not only simplified the computational effort and improved accuracy, but also better predicted small sample sizes and unbalanced datasets.

In this work, 5-fold cross-validation and “out-of-bag” (OOB) method are used to evaluate the model performance. K-fold cross-validation is a resampling procedure for evaluating machine learning models on the limited sample [39]. We validate our results by randomly partitioning data into k mutually exclusive subsets. One set is used for validation, the other $k-1$ sets are used for training. The validation process is repeated for k times. K is usually chosen to be 5 or 10, but there is no formal rule. We choose $k = 5$ in this paper. The OOB method is another evaluation method, in which OOB observations are used to create training samples [40].

3. Results

3.1. Globalization Barometers and Trend Terms on World Average

Drawing on the idea of the Global Trade Barometer of WTO [28], this paper compiles the Globalization Barometer with *de facto* and *de jure* dimensions. The steps are as follows: First, the HP filter is applied to the Globalization Index measured in Section 2, and the trend term is extracted; next, the index value is subtracted from the trend term to obtain the deviation term; finally, the deviation term is normalized and added by 100, and compared against the barometer standard interval. The standard barometer interval is set by taking 100 as the baseline, and the intervals (99, 101), (101, $+\infty$), and ($-\infty$, 99) are defined as “in trend” (yellow), “above trend” (green), and “below trend” (red), respectively.

Figure 2 shows the *de facto* and *de jure* Globalization Barometer, as well as the trend components. In terms of *de facto* globalization, the trend term is generally upward. During the past two decades, two global events, i.e., the 2008 financial crisis and the COVID-19 outbreak in 2020, influenced its progress, as shown by the grey areas. The financial crisis in 2008 caused a significant dip in *de facto* globalization. The *de facto* Globalization Barometer soared to 101.58 on the eve of the 2008 crisis, and then fell to the bottom of 98.84 when the crisis started to spread, turning from “above trend” to “below trend”. Since then, *de facto* globalization resumed its positive development until the pandemic hit the world in 2020, when *de facto* globalization suffered an even greater fluctuation. As shown in Figure 2b, a significant “above trend” could be observed in 2019, before a sharp drop to “below trend” in 2020, when the pandemic began to exert its negative influence on the world economy as well as other aspects of human lives. Moreover, the pandemic even caused the trend component to decrease. This is partly a reflection of the fragility and relative instability of globalization, where global events at the economic, social or political level could destabilize the level of *de facto* globalization. Overall, however, a positive trend is evident in *de facto* globalization.

The *de jure* globalization shows a relatively flat upward trend in general, which is also impacted by the 2008 crisis and the 2020 pandemic. The 2008 crisis had a lagging effect on the *de jure* globalization. Since 2010, there has been a general slowdown in the growth of *de jure* globalization, even if it remained positive until 2020. The *de jure* Globalization Barometer fell from 101.86 (above trend) in 2008 to 98.71 (below trend) in 2011. From 2018 onwards, *de jure* globalization remained at the previous level until 2020 when *de jure* globalization dipped following the outbreak of the COVID-19 pandemic. The trend component eventually fell, and the barometer dropped to 98.41 (below trend). The above results further illustrate the continuing negative impact of the crisis on *de jure* globalization.

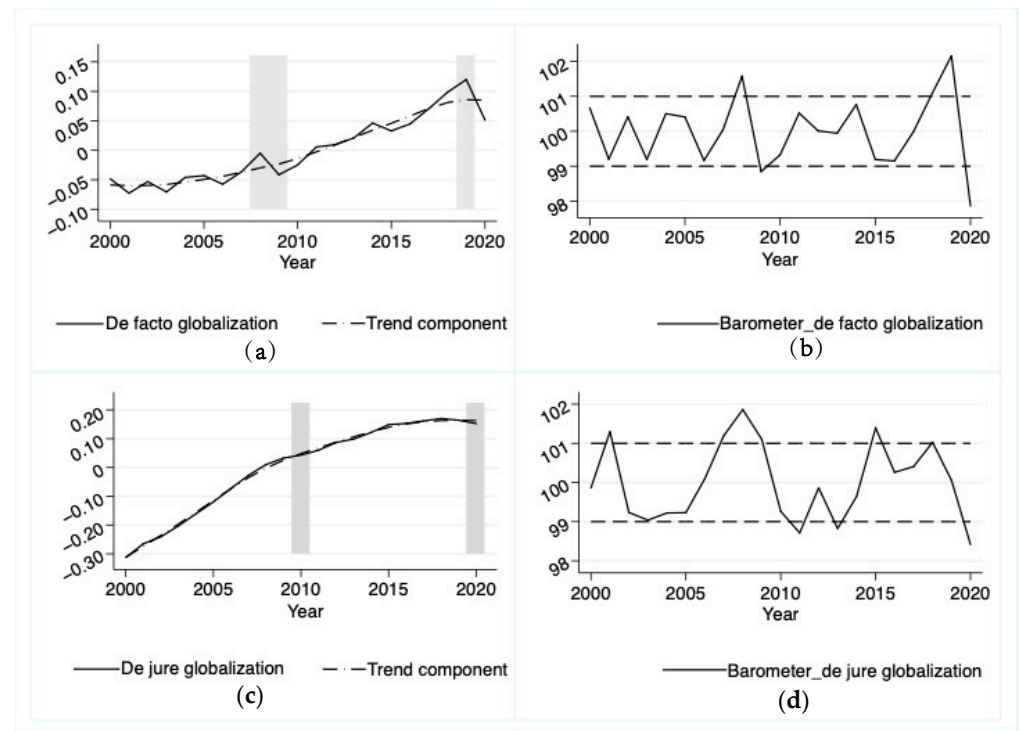


Figure 2. Barometers and trend terms of *de facto* and *de jure* globalization. (a) *De facto* globalization trend term. (b) *De facto* globalization barometer. (c) *De jure* globalization trend term. (d) *De jure* globalization barometer.

Figure 3 shows the *de facto* and *de jure* Globalization Barometer for 2020. In 2020, the *de facto* Globalization Barometer of 97.86 was “below trend”. The *de jure* Globalization Barometer was 98.41, also “below trend”. The results show that the pandemic in 2020 has challenged the development of globalization in the world and has dealt a huge blow to the globalization process.

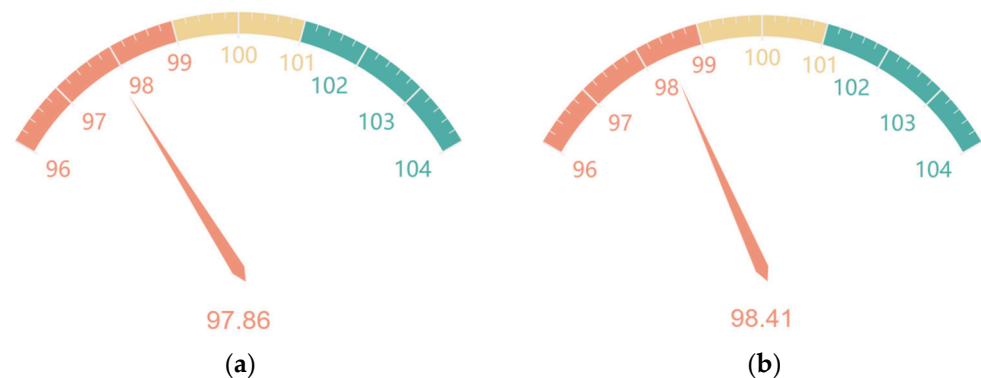
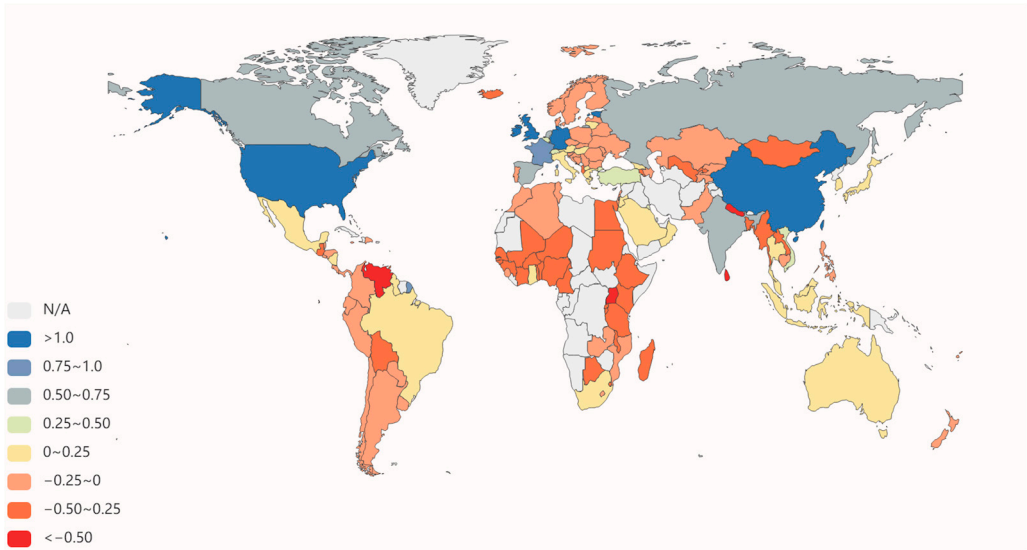


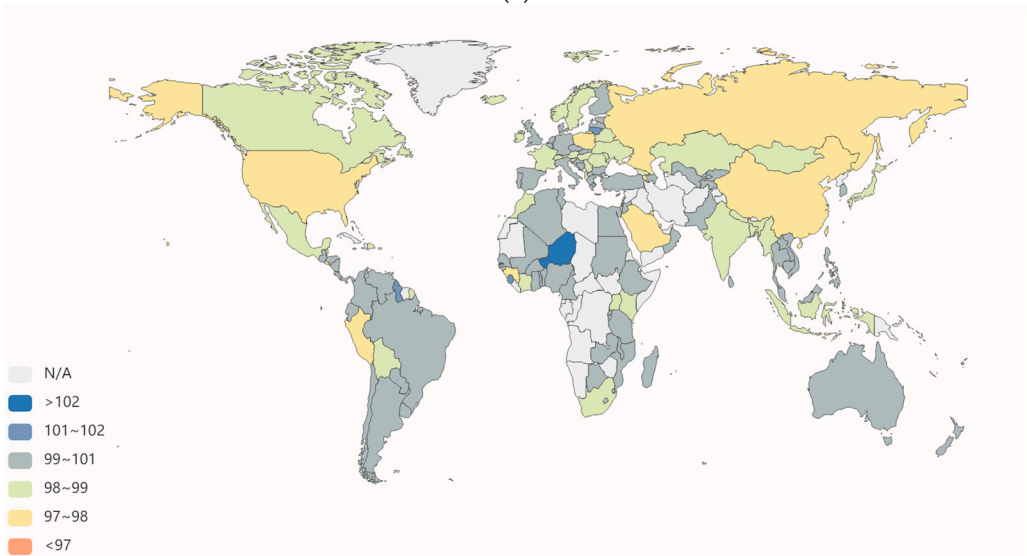
Figure 3. Globalization barometer. (a) *De facto* globalization barometer. (b) *De jure* globalization barometer.

3.2. Spatial Variations

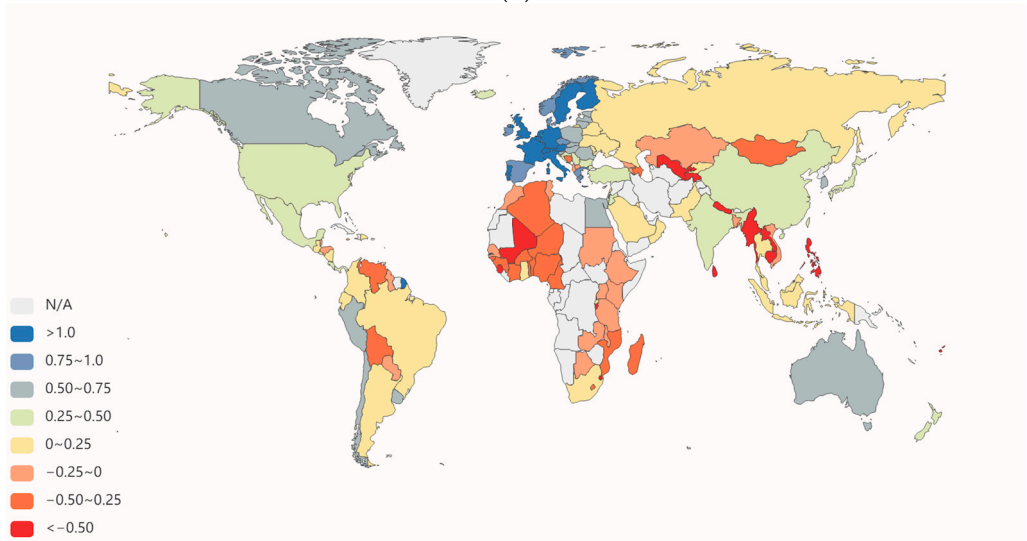
For further analysis, we have systematically analyzed the level of *de facto* and *de jure* globalization and barometers for all sample economies. The spatial variations of *de facto* and *de jure* globalization and their barometers in 2020 are illustrated in Figure 4. We observe that the variations of *de facto* and *de jure* globalization are characterized by regional spatial agglomeration.



(a)



(b)



(c)

Figure 4. Cont.

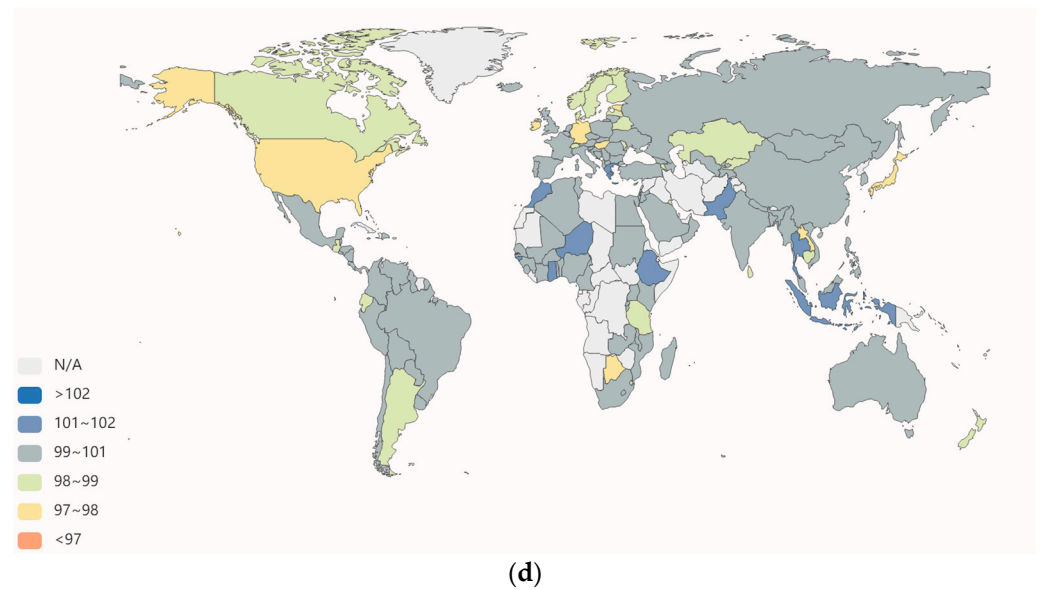


Figure 4. Spatial variation of the globalization index and globalization barometer in 2020. (a) Spatial variations of *de facto* globalization. (b) Spatial variations of *de facto* globalization barometer. (c) Spatial variations of *de jure* globalization. (d) Spatial variations of *de jure* globalization barometer.

For *de facto* globalization and its barometer in 2020, we can observe the following, as illustrated in Figure 4a,b:

- (1) Economies with higher *de facto* globalization tend to cluster in the North America, North-Eastern Asia, and Europe. For instance, the *de facto* globalization of the United Kingdom, the United States, Germany, China, and France were higher than 1.0, which indicates that their participation level surpassed the global average by at least one standard deviation.
- (2) Comparatively speaking, South America, Central Asia, Central, and Eastern Europe, and Africa were less involved. For instance, the *de facto* globalization of Uganda, Nepal, Venezuela, and Sri Lanka were less than -0.50 .
- (3) The Barometers of different regions and countries were also differentially impacted by the pandemic. Interestingly, we have found a greater impact in economies with more involvement in globalization. Economies with traditionally high *de facto* globalization values, such as China, Russia, and the US, ranked lower in the barometer, scoring 97.74, 97.55, and 97.53, respectively. Meanwhile, countries with lower *de facto* globalization were less exposed to shocks, especially those in South America, Central Asia, and Africa as well as Oceania, with economies sitting at or above trend. These results indicate that the impact of the pandemic on globalization is not uniform across the globe, serving as an equalizer of sorts, leveling the differences in globalization participation in the post-COVID world.

Second, let us focus on the *de jure* globalization and its barometer in 2020. From Figure 4c,d, we can observe:

- (1) Economies in Western Europe, Northern Europe, and North America tend to have higher *de jure* globalization scores, with the *de jure* globalization of France, Germany, Netherlands, Belgium, and the United Kingdom higher than 1.0.
- (2) Certain countries or regions showed lower *de jure* participation, especially those in South America, Central Asia, and Africa, with the Philippines, Myanmar, Fiji, Sri Lanka, and Uzbekistan scoring less than -0.50 .
- (3) Of note, the *de jure* globalization of most countries has not been significantly hampered by the pandemic. The proportion of countries with the barometer of *de jure* globalization above or in trend was about 74.6%. Only North America and a few countries in Asia and Europe were below trend, including Germany, Japan, and the

United States, scoring 97.86, 97.77, and 97.55 in 2020, respectively. Compared with *de facto* globalization, *de jure* globalization was more stable.

3.3. Driving Forces

Figure 5 presents the three-dimensional forces, i.e., economic, social, and political factors, of the *de facto* and *de jure* Globalization Barometer for 2020.

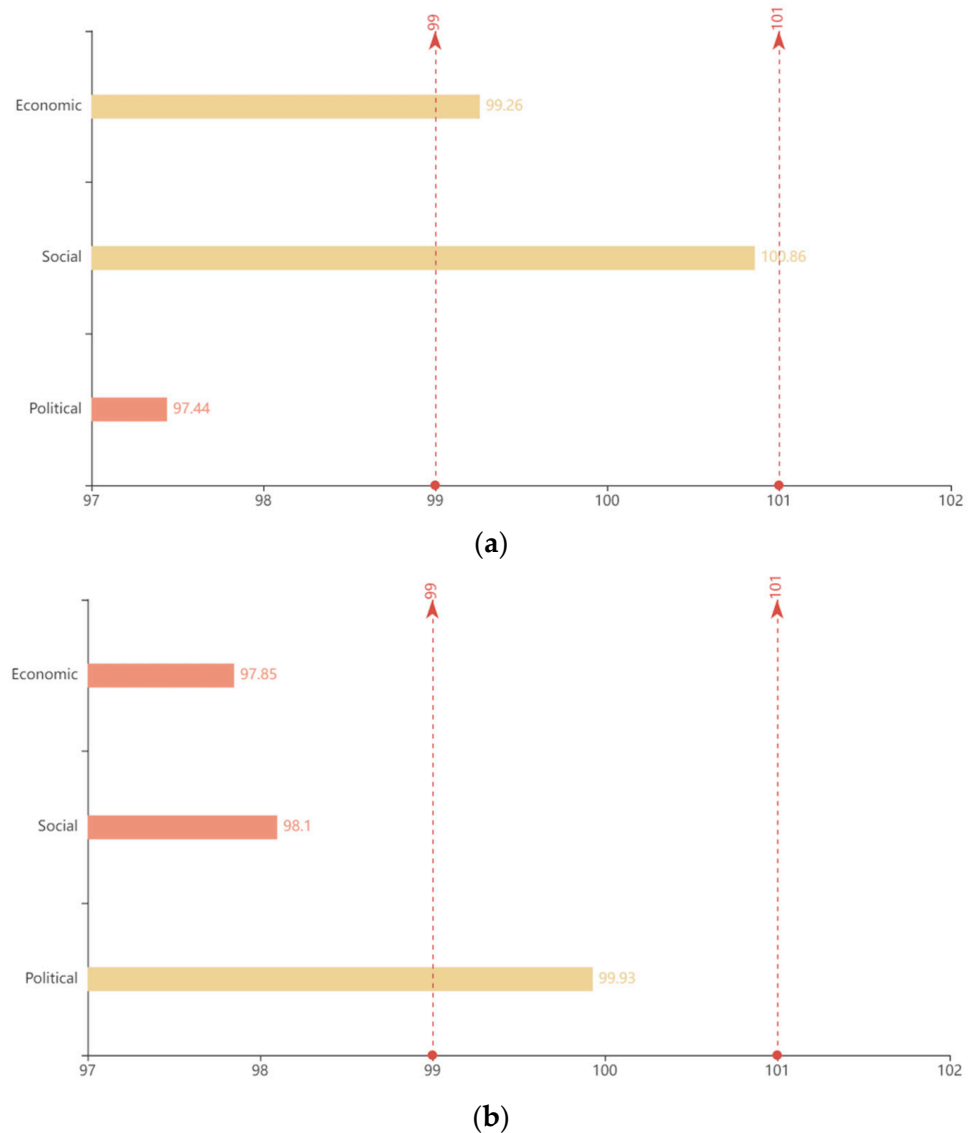


Figure 5. Three-dimensional forces of globalization barometer. (a) Three-dimensional forces of *de facto* globalization barometer. (b) Three-dimensional forces of *de jure* globalization barometer.

3.3.1. Driving Forces of *de Facto* Globalization Barometer

In 2020, the *de facto* economic Globalization Barometer was in trend (99.26). The *de facto* social Globalization Barometer was also in trend (100.86), while the *de facto* political Globalization Barometer was below trend (97.44).

First, the *de facto* economic globalization displayed remarkable buoyancy in the face of the significant shocks caused by the COVID-19 outbreak. In response to the virus, economies around the world implemented lockdowns and restrictions, generally disrupting international trade. However, after a brief negative depression, global trade quickly turned positive in the second half of 2020, as suggested by the DHL connectedness index. Mirroring this trend was the global financial markets, which responded negatively with increased

uncertainty and systematic risks during the pandemic, likely exacerbated by the loss of confidence from investors and other actors responding to more pessimistic forecasts. Yet, a general recovery in the global trade was thought to have contained the panic in the global financial markets, contributing to more stability and positive prospects regarding international capital flows.

Second, *de facto* social globalization is characterized by structural differences. Restrictions on international travel greatly disrupted cross-border human exchange, leading to a fall in interpersonal globalization. The main means of international transportation, air transport services, including the airline industry, suffered a great blow. However, it is also worth mentioning that informational globalization boomed during the pandemic, to some extent mitigating social impacts. Limitations on public gatherings and activities led to a significant increase in online activities and far more frequent internet use compared with pre-pandemic times, which fostered thriving online communities. The exchanges of information became considerably more efficient thanks to the internet, and informational globalization acted as a major counter-weight against the negative impact of interpersonal globalization. Therefore, *de facto* social globalization maintained a mildly steady trend in 2020.

Third, as for political globalization, both international cooperation and governance displayed a downward trend in the post-pandemic period. A relatively lower speech contribution in UN conferences, which brings more uncertainty to political globalization, may provide one of the reasonable explanations for the trend.

Overall, there are well-grounded reasons to expect the optimistic development of economic and social globalization in the short-term, whereas more attention needs to be paid to the dynamics of *de facto* political globalization.

3.3.2. Driving Forces of *de Jure* Globalization

In 2020, the *de jure* economic Globalization Barometer is falling at 97.85, far below trend; the *de jure* social Globalization Barometer is 98.1, also “below trend”; the *de jure* political Globalization Barometer is 99.93, in trend.

First, before the pandemic, populism and protectionism actions by several economies have stirred up hostile emotions in international trade. These emotions were exacerbated by the 2020 global health crisis and its concomitant economic fallout, as economies trying to establish new trade agreements diverted strategies to cope with the ongoing pandemic. Consequently, fewer trade agreements have been signed since the onset of the pandemic. According to the United Nations Treaty Collection, 356 trade agreements were signed in 2020, six less than in 2019; 437 trade agreements entered into force in 2020, 51 less than in 2019.

Second, when considering *de jure* social globalization, the clear inconvenience caused by restrictive measures discouraged international human exchange, especially cross-border travel. The construction of new airports also slowed down due to a decrease in international traffic demand, following a decrease in visas issued due to stricter border controls and other relevant COVID-19 countermeasures. An inactive trend in interpersonal infrastructure was one of the major factors that explained the falling trend of *de jure* social globalization.

Third, from the perspective of *de jure* political globalization, international organizations, especially World Health Organization, have been working around the clock to mitigate the global impact of the pandemic with programs, such as the COVAX initiative for worldwide vaccine distribution. Furthermore, relaxed restrictions related to the pandemic lead to a recovery of some UN peacekeeping missions around the world, leading to higher participation in peacekeeping missions and indicating that political globalization is regaining its strengths.

3.4. Forecasting Globalization Trends

Following Petukhova et al. [41], we use the Random Forest model to predict the time-series data. The *de facto* and *de jure* globalization, as well as the economic, social, and

political dimensions, for the subsequent 5 years after 2020 are predicted and analyzed in this section.

In this paper, eight Random Forest models were built based on eight dimensions, i.e., the *de facto* and *de jure* globalization and the three subdimensions of each. For example, the dependent variable is the *de facto* globalization for each economy in period t , and the independent variables would be set to be the *de facto* globalization for each economy in period $t-n$ to $t-1$. To expand the sample size, we chose $n = 10$. Since our sample spans from year 2000 to 2020, period t would be from year 2010 to 2020. In this way, we use data of each dimension as dependent variables, and the independent variables are set as the previous 10-year data for the corresponding dimension.

We used 5-fold cross-validation to find the set of parameters with the best prediction results and chose parameters with the number of subtrees of 100, a minimum number of samples required for internal node subdivision of 2, a minimum number of samples for leaf nodes of 1, and the maximum number of features used for a single decision tree is \sqrt{N} (N is the total number of features). The performance of the model was evaluated by the coefficient of determination (R^2), root mean squared error (RMSE), and mean absolute error (MAE) via 5-fold cross-validation (CV) and the “out-of-bag” (OOB) method. The R^2 are all above 84%, the RMSE and MAE are small for all eight models. The model is generalized well, with no overfitting occurring. The detailed model evaluation results are shown in Table 2.

Table 2. Model evaluation results.

Dimension	5-Fold Cross-Validation			Out-of-Bag		
	R^2	RMSE	MAE	R^2	RMSE	MAE
<i>De facto</i> globalization	0.9502	0.0129	0.0628	0.9508	0.0126	0.0620
<i>De facto</i> economic globalization	0.9750	0.0248	0.0630	0.9818	0.0190	0.0551
<i>De facto</i> social globalization	0.8731	0.0608	0.0697	0.8486	0.0490	0.0649
<i>De facto</i> political globalization	0.9400	0.0469	0.1344	0.9390	0.0462	0.1335
<i>De jure</i> globalization	0.9864	0.0038	0.0366	0.9865	0.0037	0.0357
<i>De jure</i> economic globalization	0.9896	0.0088	0.0576	0.9899	0.0085	0.0560
<i>De jure</i> social globalization	0.9885	0.0035	0.0332	0.9903	0.0029	0.0310
<i>De jure</i> political globalization	0.9459	0.0257	0.0668	0.9547	0.0228	0.0624

After training the model, we used the 10-year data from 2011 to 2020 to forecast the result of 2021. Then, with the predicted data of 2021 as one of the features, we used the data from 2012 to 2021 to forecast the result in 2022, followed by four more periods of prediction from 2022 to 2025 using the same method.

Model Results

Figure 6 shows prediction results for globalization trajectory using the Random Forest model. Both *de facto* and *de jure* globalization are projected to exhibit a steady upward trend in the next five periods after 2020.

The projected *de facto* globalization for 2021 to 2025 is as follows: A significant rebound is expected for 2021, describing a “V” curve. After the rebound, *de facto* globalization is highly likely to follow a steady upward trajectory for the remainder of the 5 years; *de facto* economic globalization in the same 5-year period would experience a large-scale rebound; *de facto* social globalization would decrease in 2021, followed by a steady, gradual recovery; while *de facto* political globalization has the potential to experience a large-scale rebound in 2021, followed by a steadily increasing trend.

The *de jure* globalization trend in general may remain relatively stable. For the next 5 years, *de jure* globalization is projected to maintain steady yet slow levels of upward momentum. *De jure* economic globalization keeps pace with overall globalization, i.e., a rebound to form a “V” curve, tapering into a slow increase; *de jure* social globalization

maintains a slowly upward pace for this period; while *de jure* political globalization is expected to maintain its previous level for 2021, and increases after 2022.

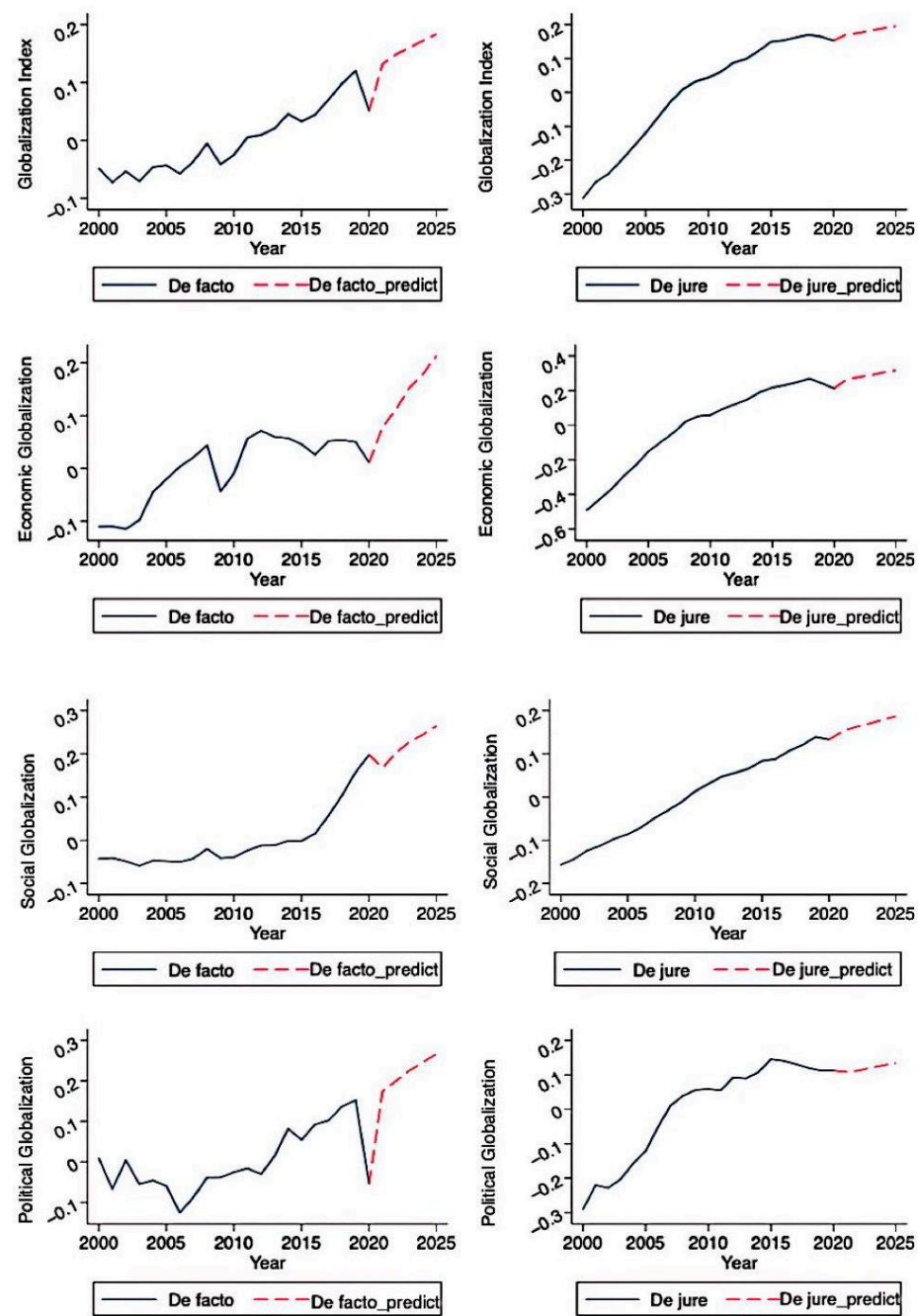


Figure 6. Forecasting of the globalization trends.

4. Discussion

The globalization trend impacts the economic, social, and political development of all countries around the world, making it a highly relevant topic of discussion. Current literature is limited to qualitative judgements or point-quantifications, leaving the broader stroke issue of trend largely untouched. In order to fill the gap, we developed the Globalization Barometer to evaluate the trend of globalization in more depth.

We constructed a Globalization Index based on existing indices and used the HP filter method to decompose the trend and deviation terms, of which the latter is used to construct the Globalization Barometer. Our results indicate that since 2000, *de facto* and

de jure globalization generally maintained an upward trajectory. The 2008 financial crisis and the 2020 COVID-19 pandemic have negatively impacted globalization trends, serving as turning points on the curve. From a world average perspective, *de facto* globalization saw a significant setback post the 2008 financial crisis, followed by a rapid rebound until the pandemic in 2020. *De jure* globalization generally maintained steady growth but also experienced the shocks of the two crises, including the 2008 slowdown in growth and the dip in trend in 2020. Our results are intuitive and support previous observations [5,7].

Although the 2020 pandemic has exerted a negative impact on globalization, it is well-worth noting the unexpected positive effect of reducing the gap in *de facto* and *de jure* globalization. Further analysis revealed an uneven distribution of globalization across the world. We find that economies in North America, Northeast Asia, and Europe feature high *de facto* globalization; on the other hand, economies with high *de jure* globalization are generally concentrated in Western Europe, Northern Europe, and North America. However, the spatial variation of globalization barometer shows that the impact of the pandemic is not evenly felt around the world. Economies with higher scores in *de facto* and *de jure* globalization experience greater shocks, while economies with lower scores remain relatively untouched. Our results complement current literature on globalization trends and the pandemic's impacts and threats [8,9] while also adding to the current debate the argument that the impact of globalization mainly was felt in a few economies and regions and may help form a more balanced post-COVID global paradigm.

By deconstructing the driving forces of globalization, our research shows uneven levels of globalization across the economic, social, and political dimensions. *De facto* globalization grew below trend with economic and social globalization on trend, and political globalization below trend. *De jure* globalization turned out to be below trend as well for this year, due mainly to economic and social globalization's downturn compared with political globalization. Our results indicate that albeit the fact that the current development of globalization in general failed to meet our expectations, there are still positive dimensions in globalization, and may serve as the future driving forces of stable and positive development.

Finally, we have also used the Random Forest model to conduct time-series predictions for the years between 2021 and 2025. For the subsequent 5 years, *de facto* and *de jure* globalization will likely maintain an upward trajectory, thereby providing quantitative, machine learning-backed response to current qualitative research on future globalization trends.

5. Conclusions

In summary, our research has confirmed and complemented existing studies on globalization trends in the following two aspects. Approach-wise, our research adopted appropriate methods to quantify globalization trends. Although these methods, including the HP filter and Random Forest, are not novel in the scientific community, we are one of the early adopters of these methods in the research of globalization. Conclusion-wise, our research can adequately respond to the theoretical debates on the direction of post-pandemic globalization trend within the greater sphere of sociology and international relations. For instance, Contractor [2] believes the pandemic has a short-term impact from which the world will recover soon, while Ciravegna and Michailova [12] believe that the pandemic "will have significant long-lasting effects on globalization." Additionally, even fewer researchers conduct detailed and in-depth discussions on the globalization trend due to the lack of quantifiable metrics. Our paper fills in the theoretical gap and comes to an unexpectedly interesting conclusion that the pandemic has decreased the uneven distribution of globalization.

Other than academic research, globalization quantification can be used by business analysis, mass and specialized media, and public policy. Stakeholders can make informed predictions and decisions on globalization trends using the Globalization Barometer. Companies can adjust how they deploy their regional investment strategy and transnational operations. Media can use the barometer to provide their audience with a more neutral

and accurate image of globalization. In addition, policymakers can reference this research to set foreign policy and international relations decisions.

Considering the complicated nature of globalization development, quantifiable trend analysis will continue to pose a challenge for academia. Our paper is an exploratory attempt at quantifying globalization and is far from perfect. For the future, we will focus on: (1) The barometer's application and validation using more variables and time-series; (2) more detailed study on national or regional globalization trends that were excluded in this paper due to space constraints; and (3) a more in-depth study on the driving factors of globalization to better aid globalization development trend analysis.

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Appendix A

Table A1. Measurements of all indicators in the globalization index.

Primary Indicators	Secondary Indicators	Tertiary Indicators	Measurements
Economic	Trade	<i>de facto</i> Trade in products	goods imports and exports (% of GDP)
			service imports and exports (% of GDP)
		<i>de jure</i> Tariffs	the unweighted mean of custom duties
			the number of trade agreements
	Financial	Foreign direct investment (FDI)	the inbound and outbound flows of FDI (% of GDP)
		<i>de facto</i> Portfolio investment (PI)	the inbound and outbound flows of PI (% of GDP)
		International income payments (IIP)	the asset and liability of IIP (% of GDP)
		Capital account openness	Chinn-Ito index
		<i>de jure</i> International investment agreements	the total number of Bilateral Investment Treaties (BIT) and Treaties with Investment Provisions (TIP)

Table A1. Cont.

Primary Indicators	Secondary Indicators	Tertiary Indicators	Measurements
Social	Informational	<i>de facto</i> Used internet bandwidth	international bandwidth measured in Mbit/s
		<i>de jure</i> Internet access	the total of individuals using the Internet (% of population)
	Interpersonal	International tourism	the inbound and outbound tourists (% of population)
		<i>de facto</i> International students	the inbound and outbound tourists (% of population)
		Migration	the immigrants and emigrants (% of population)
		<i>de jure</i> Freedom to visit	the number of visa-free countries or regions
		International airports	the number of international airports (% of population)
	Technological	International patents	the nonresident-applied patents (% of total)
		<i>de facto</i> High technology exports	the high-tech exports (% of manufactured exports)
		<i>de jure</i> Global innovation index	Global innovation index
	Cultural	<i>de facto</i> Trade in printed goods	the imports and exports in printed goods HS Code 49 (% of GDP)
		International trademarks	the nonresident-applied trademarks (% of total trademarks)
		<i>de jure</i> Social tolerance index	Social tolerance index
		<i>de jure</i> Language popularity index	foreign nationals speaking the majority language of that country (% of total speakers)
Political	International Cooperation	<i>de facto</i> Foreign affairs agencies	the sum of embassies, consulates, permanent missions, and other representations
		<i>de jure</i> International organizations	the number of international organizations
		<i>de jure</i> International treaties	the number of international treaties signed after 1945 and ratified by the legislative organization
	Global governance	<i>de facto</i> Speech contribution in UN	the total speech number made in UN
		<i>de jure</i> UN peacekeeping contribution	the number of peacekeeping personnel

Table A2. The structure of the original and selected dataset.

Categories		Original		Selected	
		Number	Percentage	Number	Percentage
Geographic Location	Europe and Central Asia	58	26.73%	46	32.39%
	Sub-Saharan Africa	48	22.12%	33	23.24%
	Latin America and Caribbean	42	19.35%	25	17.61%
	East Asia and Pacific	37	17.05%	19	13.38%
	Middle East and North Africa	21	9.68%	12	8.45%
	South Asia	8	3.69%	5	3.52%
	North America	3	1.38%	2	1.41%
Income Group *	High income	79	36.57%	65	45.77%
	Lower middle income	55	25.46%	39	27.46%
	Upper middle income	55	25.46%	33	23.24%
	Low income	27	12.50%	5	3.52%

* Venezuela, RB was not assigned to any income group when data were collected.

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