Coquidé *et al. Applied Network Science* (2023) 8:65
https://doi.org/10.1007/s41109-023-00590-3

Applied Network Science

RESEARCH Open Access

Prospects of BRICS currency dominance in international trade

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Abstract

During the April 2023 Brazil–China summit, the creation of a trade currency supported by the BRICS countries was proposed. Using the United Nations Comtrade database, providing the frame of the world trade network associated to 194 UN countries during the decade 2010–2020, we study a mathematical model of influence battle of three currencies, namely, the US dollar, the euro, and such a hypothetical BRICS currency. In this model, a country trade preference for one of the three currencies is determined by a multiplicative factor based on trade flows between countries and their relative weights in the global international trade. The three currency seed groups are formed by 9 eurozone countries for the euro, 5 Anglo-Saxon countries for the US dollar and the 5 BRICS countries for the new proposed currency. The countries belonging to these 3 currency seed groups trade only with their own associated currency whereas the other countries choose their preferred trade currency as a function of the trade relations with their commercial partners. The trade currency preferences of countries are determined on the basis of a Monte Carlo modeling of Ising type interactions in magnetic spin systems commonly used to model opinion formation in social networks. We adapt here these models to the world trade network analysis. The results obtained from our mathematical modeling of the structure of the global trade network show that as early as 2012 about 58% of countries would have preferred to trade with the BRICS currency, 23% with the euro and 19% with the US dollar. Our results announce favorable prospects for a dominance of the BRICS currency in international trade, if only trade relations are taken into account, whereas political and other aspects are neglected.

Keywords: World trade network, International trade, Currency, Opinion formation model

Introduction

Starting from the Bretton Woods agreements in 1944, the US dollar (USD) was keeping its dominant position in international trade (Wikipedia contributors 2023b). Naturally, the United Nations (UN) reports world trade transactions between countries in USD (United Nations Statistics Division 2023). However, in the last years, a clear tendency emerged to perform trade between certain firms or between certain countries in other currencies than USD. Thus, Saudi Arabia considers using Chinese yuan (CNY) instead of USD for the oil sales to China (Said and Kalin 2022). There are also other multiple

indications that the USD dominance in the world trade is decreasing (see e.g. discussions in Raisinghani (2022), Ahmed (2022), Global Times writers 2022, Amadeo (2022), Curran (2022), Liu and Papa (2022)), Nikkei staff writers 2022. As an example, CNY becomes the most traded foreign currency on the Moscow Exchange and surpasses USD (Global Times writers 2022; Nikoladze and Bhusari 2023). In addition, recently, Brazil and China have allowed themselves to carry out commercial and financial transactions directly in CNY or in Brazilian reais (BRL) without resorting to a conversion into USD (Bradford Betz 2023).

In such an atmosphere of de-dollarization of international trade, the Brazilian representatives' call, made during the April 2023 Brazil–China summit, to create a new BRICS currency to end the trade dominance of the dollar has aroused great interest and great concern (see e.g., Leahy and Lockett 2023; Yeh 2023). Thus, it is timely to ask the question of the impact of the creation of such a new BRICS currency on international trade. Formerly, during the Soviet era, a special currency, the tranfer ruble pegged to the Soviet ruble, was used to compute the value of the trade and the debts between countries of the Eastern bloc which were members of the COMECON. This currency, used in a partitioned world, disappeared with the fall of the Berlin Wall. It is thus interesting to probe the influence of a new currency in today's open international trade. Here we present a mathematical analysis of the possible influence of a new BRICS currency, hereafter referred to as BRI, using international trade data. More precisely, we develop a model to determine the mathematical preference of a given country to trade in a specific currency which may be different from USD. Such a mathematical model is built on the World Trade Network (WTN) which is determined from the UN Comtrade database (United Nations Statistics Division 2023) for the period 2010–2020. This database gives the volumes of monetary transactions between all the countries during a given year: The money matrix element $M_{c'c}$ gives the total amount of commodities, expressed in USD of a given year, exported from the country c to the country c'. These money matrix elements $M_{c'c}$ can be used to construct the Markov chain of trade transactions from which the WTN.

At present the complex network description finds useful applications in various fields of science including social networks, World Wide Web, biological networks, brain networks and others (see e.g. Dorogovtsev 2010). The complex network properties of the WTN have been studied in Serrano et al. (2007), Fagiolo et al. (2009), He and Deem (2010), Fagiolo et al. (2010), Barigozzi et al. (2010), Chakraborty et al. (2018), De Benedictis and Tajoli (2011). The Google matrix method (Langville and Meyer 2006; Ermann et al. 2015) have been applied to the WTN in Ermann and Shepelyansky (2011) with the PageRank (Brin and Page 1998) construction and in Ermann and Shepelyansky (2011), Coquidé et al. (2019) with the use of PageRank and CheiRank vectors which characterize import and export flows, respectively. It was shown that PageRank and CheiRank probabilities obtained from the Google matrix allow to analyze a crisis contagion in the WTN (Coquidé et al. 2020).

The analysis of the competition between two or three currencies in the WTN requires the development of a new approach compared to previous WTN studies where all transactions are expressed in USD. In the case of two currencies competition (e.g., USD and CNY), the situation is similar to the problem of spin magnetization, e.g. Ising model,

or opinion formation on simple lattices and complex networks. Indeed, in spin lattice systems, e.g., a spin up surrounded by spins down has a tendency to turn down, taking the direction of dominant neighboring spins. A similar situation appears also in the problem of opinion formation on simple lattices or complex networks when there is a competition between two opinions or two votes for two different parties. Various models of opinion formation were proposed and investigated (see e.g. Galam 1986; Liggett 1999; Galam 2005; Watts and Dodds 2007; Galam 2008; Castellano et al. 2009; Krapivsky et al. 2010; Schmittmann and Mukhopadhyay 2010). For directed social networks, it was pointed that PageRank weight of nodes (or voters) can play an important role in an opinion formation process (Kandiah and Shepelyansky 2012; Eom and Shepelyansky 2015). We note that Ising spin models have also been applied to simulate stock market behavior (Roehner and Sornette 2000; Zhou and Sornette 2005; Sornette and Zhou 2006) and that, in macroeconomy, lattice models have been used to model competition between economic regions (Ausloos et al. 2003, 2004a, b).

The opinion formation model approach based on PageRank probabilities of complex network nodes (Kandiah and Shepelyansky 2012; Eom and Shepelyansky 2015) has been extended and applied in Coquidé et al. (2023) in order to analyze the trade preferences of world countries to perform transactions in USD or CNY. A trade currency preference (TCP) for a given country, i.e., whether the country would prefer to trade in one or another currency, is determined by two multiplicative factors, namely, the relative trade volume exchanged with its trade partners and the global weight of these partners in the global WTN. The results obtained in Coquidé et al. (2023) show that starting from 2016, the majority of countries in the world would prefer to trade in CNY and no longer in USD as it was the case before 2016. Of course, these results are based solely on the mathematical analysis of the WTN transactions and do not take into account political relations between countries. Also, according to the results obtained from the two currencies model (Coquidé et al. 2023), the eurozone (EU) countries are in 2019 on the brink of a USD-to-CNY transition of their trade currency preference. However, EU countries usually perform their internal trade in euro (EUR) which is also the second most traded currency in the world. Consequently, this matter of fact should be taken into account. Alongside, the hypothetical appearance of a new BRICS currency (BRI) implies that the BRICS countries perform trade between them only in BRI. Thus, we model the situation where the international trade is based on three currencies, namely USD, EUR and BRI. We assume that, similarly to the creation of the euro in the eurozone, the composite BRI currency is based on the currencies of the BRICS countries, i.e., the Brasilian real (BRL), the Russian ruble (RUR), the Indian rupee (INR), the Chinese yuan (CNY), and the South African rand (ZAR).

In our mathematical analysis, we determine a TCP for a given country indicating that this country has a structural advantage to trade with other countries in BRI, EUR, or USD. This characteristic TCP is based on the trade flows between countries obtained from UN Comtrade database (United Nations Statistics Division 2023). Extending the approach of Coquidé et al. (2023), we assume that the trade between two countries can be performed in one of the three currencies BRI, EUR, and USD. We also define three

currency seed groups constituted by countries for which the TCP is always the same. The BRICS group is formed by the BRICS countries, i.e., Brazil, Russia, India, China, and South African. The Anglo-Saxon group is formed by Australia, USA, UK, Canada, and New Zealand. The EU9 group is formed by Austria, Belgium, France, Germany, Italy, Luxemburg, Netherlands, Portugal, and Spain. The choice of the 9 EU countries follows the historical and economical analysis (Saint-Etienne 2018) which points out their strong inter-relations. Also, the WTN analysis reported in Loye et al. (2021) shows a significant strength of this group in the international trade. The number of inhabitants of the Anglo-Saxon and the EU9 groups are comparable, ~ 470 and ~ 300 millions of inhabitants, respectively, whereas the BRICS group encompasses a significant larger population, ~ 3.2 billions of inhabitants. Let us note that the countries belonging to these 3 currency seed groups never change their TCP. Countries of the BRICS group always prefer to trade in BRI, those of the Anglo-Saxon group always in USD, and those of the EU9 group always in EUR.

The article is organized as follows: the next section presents our 3 currencies model of trade preference using the WTN description of the international trade flows obtained from the UN Comtrade database (United Nations Statistics Division 2023). Then, the following sections are devoted to the results and discussions.

Model description and data sets

In this study, we propose a mathematical model of currency competition in the context of the World Trade Network. The WTN is a directed network representing trades between world countries and is constructed from the UN Comtrade database (United Nations Statistics Division 2023) which describes imports and exports of about 10^4 products between the world countries and territories. Here, we consider yearly trades between $N = 194$ countries for the period 2010–2020. In the WTN, the $c' \to c$ link denotes an export from the country c' to the country c and its weight $M_{cc'}$ is the corresponding exchanged money volume expressed in USD of the considered year. Hence, we note $M_c = \sum_{c'} M_{cc'}$ ($M_c^* = \sum_{c'} M_{c'c}$) the total import (export) volume associated to the country c. Also, we note $M = \sum_c M_c = \sum_c M_c^*$ the total money volume exchanged in the WTN.

The proposed competition model of currencies is an extended version of the model of two currencies studied in Coquidé et al. (2023), where only USD and CNY were considered. Such a model is similar to opinion formation models applied on social networks to study voting systems coalition formation, strike phenomena (see Galam 2008; Castellano et al. 2009 for reviews) and on numeric social network such that Twitter (Kandiah and Shepelyansky 2012). Here, we propose a model which takes account of 3 currencies, namely, USD, EUR, and BRI. The TCP of a given country depends, both, on the TCP of the other countries and on the probability to import and export with its partners. We consider two stochastic matrices, S and S^*, encoding import and export trade probabilities between all the countries which constitute the WTN. The matrix element $S_{cc'} = M_{cc'}/M_{c'}^*$ ($S_{cc'}^* = M_{c'c}/M_{c'}$) gives the ability of the country c' to export to (to import from) the country c. Also, we define the global import and export trade ability

of a country as $P_c = M_c/M$ and $P_c^* = M_c^*/M$, respectively. The TCP of the country c is a ternary variable $¢$ which takes the values $¢ =$ USD, $¢ =$ EUR, and $¢ =$ BRI. The $¢$ values of the countries belonging to the EU9 group, the Anglo-Saxon group and the BRICS group are kept fixed all along the simulation. For the rest of the world, the TCPs, i.e., either EUR, USD or BRI, are initially randomly affected to the other countries. Hence, the fraction $f_i^{¢}$ of the world countries initially possess a TCP $¢$ with $f_i^{\mathrm{USD}} + f_i^{\mathrm{EUR}} + f_i^{\mathrm{BRI}} = 1$. This initial preparation constitute the step $\tau = 0$ of the Monte Carlo process. Then, we successively pick at random each one of the N countries for which we compute the following three trade currency scores

$$Z_{¢} = \frac{\sum_{c' \neq c} \delta_{¢,¢'} (S_{c'c} + S^*_{c'c})(P_{c'} + P^*_{c'})}{\sum_{c' \neq c} (S_{c'c} + S^*_{c'c})(P_{c'} + P^*_{c'})}, \tag{1}$$

one for each currency $¢ =$ USD, EUR, and BRI. In the above equation the sum runs over all the countries c' excepting the country c for which we compute the quantity $Z_{¢}$, the symbol $¢'$ stands for the TCP of the country c', and the Kronecker symbol $\delta_{¢,¢'}$ is equal to 1 if $¢ = ¢'$, and 0 otherwise. The denominator ensures that the sum of the trade currency scores is equal to 1, i.e., $Z_{\mathrm{USD}} + Z_{\mathrm{EUR}} + Z_{\mathrm{BRI}} = 1$. The $S_{c'c} + S^*_{c'c}$ factor encodes the relative commercial strength between the country c and its direct partner c'. The factor $P_{c'} + P^*_{c'}$ encodes the global trade capacity of the commercial partner c'. Accordingly to the values of the three newly computed quantities, Z_{USD}, Z_{EUR}, and Z_{BRI}, the country c TCP possibly changes as it takes the value $¢$ such as $Z_{¢}$ is the maximal value of the three. Otherwise stated, the TCP associated to country c becomes, e.g., $¢ =$ EUR, if $Z_{\mathrm{EUR}} > Z_{\mathrm{USD}}$ and $Z_{\mathrm{EUR}} > Z_{\mathrm{BRI}}$. The step $\tau = 1$ of the Monte-Carlo process ends once all the countries have been successively picked and, consequently, may have changed their TCPs. The following τ steps of the Monte-Carlo process reproduce the step $\tau = 1$ until a steady state is reached. The average final fraction of countries $f_f^{¢}$ with a TCP $¢$ is obtained from 10^4 Monte-Carlo simulations. Each one of these simulations starts with a random initial distribution of TCPs, i.e., f_i^{USD}, f_i^{EUR}, and f_i^{BRI}.

In the appendix, Fig. 4 illustrates the convergence of the simulation. We observe that the fraction of countries with a given TCP converges rapidly after few Monte-Carlo process steps $\tau \simeq 2 - 3$. We checked that whatever are the initial fractions f_i^{USD}, f_i^{EUR}, and f_i^{BRI}, on average the system reaches always the same steady state characterized by final TCP fractions f_f^{USD}, f_f^{EUR}, and f_f^{BRI}. As an example, we obtain $f_f^{\mathrm{USD}} = 0.24$, $f_f^{\mathrm{EUR}} = 0.27$, and $f_f^{\mathrm{BRI}} = 0.49$, in 2010, and $f_f^{\mathrm{USD}} = 0.19$, $f_f^{\mathrm{EUR}} = 0.22$, and $f_f^{\mathrm{BRI}} = 0.59$, in 2019.

Results

Here we present the results obtained from the WTN analysis with the methods described in the previous section.

The world map distributions of TCPs, obtained from the Monte Carlo simulations based on the calculation of the trade currency scores (1), are shown in Fig. 1 for years 2010 and 2019. In 2010, the USD TCP is mainly localized in North and

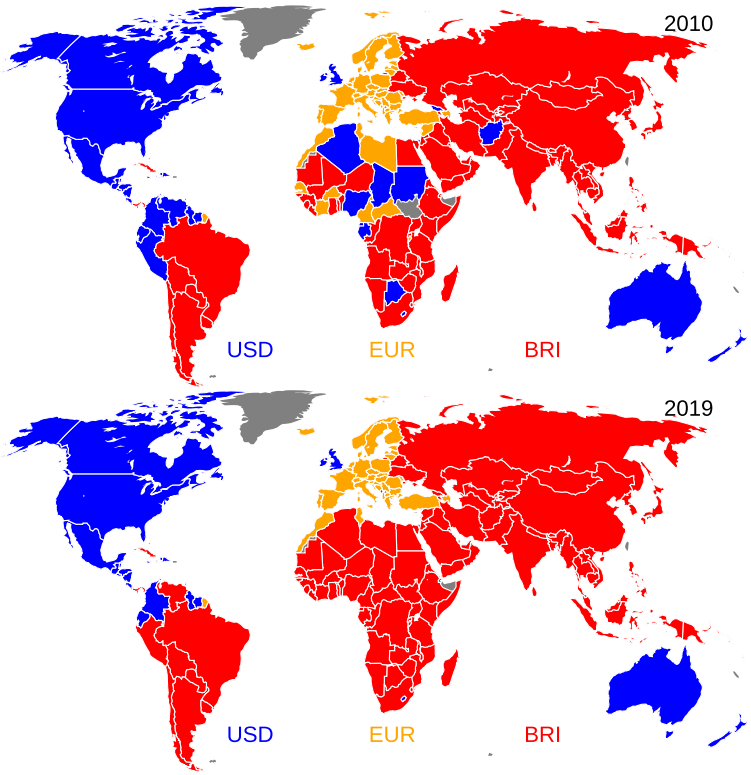

Fig. 1 World distribution of the trade currency preferences, TCP, for 2010 (top panel) and 2019 (bottom panel). Countries with a trade preference for USD are colored in blue, for EUR in gold, and for BRI in red. Countries colored in grey have no trade data reported in the UN Comtrade database (United Nations Statistics Division 2023)

Central America (excepting, Cuba and Panama which have a BRI TCP), northern South America, UK, Australia and New Zealand. The EUR TCP is mainly localized in European countries and in countries all around the Mediterranean sea with the exception of Israel and Algeria which have an USD TCP and Egypt which have a BRI TCP. The BRI TCP is located in Asian countries (excepting Afghanistan which have a USD TCP), the countries of the former Soviet Union (excepting Georgia and Azerbaijan which have a USD and EUR TCP, respectively), and the countries of South America (with the exception of the northern countries which have a USD TCP). Apart from the cited exceptions, the distribution of TCPs is quite natural. Indeed, the Americas are divided into a USD block, driven by USA and Canada, and a BRI block driven by Brazil. In Europe, the EUR TCP dominates since the EUR is the official currency of more than 20 countries of the eurozone. Finally, in Asia, the BRI TCP dominates under the influence of China, Russia and India. By contrast, Africa appears fragmented as the 3 TCPs are comparably distributed all over its countries. This image echoes the post-1989 era battle of influence on African affairs of countries such as France, USA, Russia and China. Globally, the countries of the Southern and Eastern

Africa have a BRI TCP, whereas the three types of TCP are quite homogeneously distributed in the Northern, Western and Central Africa.

From 2010 to 2019, the EUR group looses 7 countries in Africa but otherwise stays unchanged, and its influence stays focused on the European continent. From 2010 to 2019, the USD group looses its influence completely in Africa (with the exception of the Lesotho) and more mildly in South America where Venezuela and Peru have now a BRI TCP. On the other hand, from 2010 to 2019, the BRI group has spread over almost the entire African continent and has strengthened its influence in northern South America. In 2019, the BRI influence spans mostly over the developing and least developed countries (Wikipedia contributors 2023c) and the USD and EUR influences concern mostly the Western world (Wikipedia contributors 2023a).

By construction, New Zealand and Australia, belonging to the seed countries of the USD group, have always a fixed USD TCP. However, in the 2 currencies model (Coquidé et al. 2023), where only USA and China always trade in USD and CNY, respectively, New Zealand and Australia always have a trade preference for CNY instead of USD. We note also close similarities between the EUR group (see Fig. 1) and the swing group observed for 2019 in Coquidé et al. (2023) (see Fig. 4 therein). The swing group in Coquidé et al. (2023) consists in a set of countries which depending on the initial distribution of the TCPs aggregate as a whole to the USD or CNY group. This swing group (Coquidé et al. 2023) corresponds to the EUR group presented in Fig. 1 (with the addition of Algeria, Egypt, Ivory Cost, Israel and Jordan).

In the appendix, for the sake of completeness, the world distributions of the trade currency preferences for the years 2012, 2014, 2016, 2018 and 2020 are presented in Fig. 5 which shows indeed a progressive expansion of the BRI trade currency preference over the world. Also, Tables 1, 2, and 3 give the countries in the USD, EUR, and BRI groups in 2019.

In Fig. 2, the distribution of the countries' trade currency ternary scores $(Z_{\mathrm{USD}}, Z_{\mathrm{EUR}}, Z_{\mathrm{BRI}})$ are given for 2010 and 2019. As in Fig. 1, for both years, we observe the BRI group gathers more countries than the EUR and USD groups which have similar sizes (see also Fig. 3 hereafter). From 2010 to 2019, the EUR group is robust with two main clusters: one cluster located in the range $0.6 \lesssim Z_{\mathrm{EUR}} \lesssim 0.8$, strongly tied to the EUR currency, which mainly gathers Central Europe and Balkan countries, and the other cluster located in the range $0.4 \lesssim Z_{\mathrm{EUR}} \lesssim 0.6$ which mainly corresponds to Nordic countries and Baltic countries with the addition of Poland, Switzerland, Greece, Turkey, Azerbaijan and the African countries which are present in the 2010 world distribution of TCPs (see Fig. 1 top panel). From 2010 to 2019, we observe, on average, a shift of these two clusters towards the BRI group. Moreover, most of the African countries present in the EUR group in 2010 moved to the BRI group in 2019, and, e.g., Switzerland and Turkey are in 2019 located close to the $Z_{\mathrm{EUR}} = Z_{\mathrm{USD}} = Z_{\mathrm{BRI}}$ equilibrium point (in the 2020 data, Switzerland has even actually moved into the USD group). Summarizing, a non negligible part of the EUR group countries are on the brink of a transition mainly towards the BRI group. Also during the 2010–2019 period, the countries of the

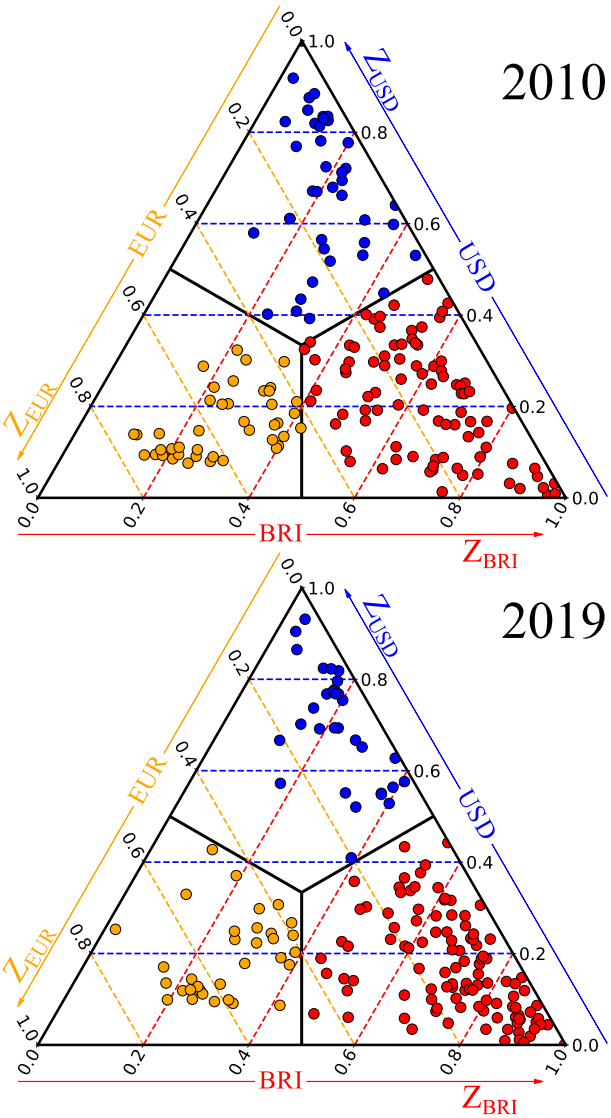

Fig. 2 Distribution of the countries' trade currency ternary scores ($Z_{USD}, Z_{EUR}, Z_{BRI}$) for 2010 (top panel) and 2019 (bottom panel). A country is represented by a circle. Colors are associated to TCPs, blue for USD, gold for EUR, and red for BRI. The Z_{USD} coordinate is read along the dashed blue horizontal lines, the Z_{EUR} coordinate along the gold dashed oblique lines, and the Z_{BRI} coordinate along the red dashed oblique lines

BRI group moved toward larger values of Z_{BRI} since in 2019 most of the countries are concentrated in the $Z_{BRI} > 0.6$ zone. This matter of fact indicates a strong entanglement between economies of the BRI group and, mechanically, a weaker dependence on the countries of the EUR and USD groups. More strikingly, we observe in 2019 that most of the USD and BRI groups countries are located in the $Z_{EUR} < 0.2$ zone which suggests that the European countries economies tend to loose their influence on the extra-European economies.

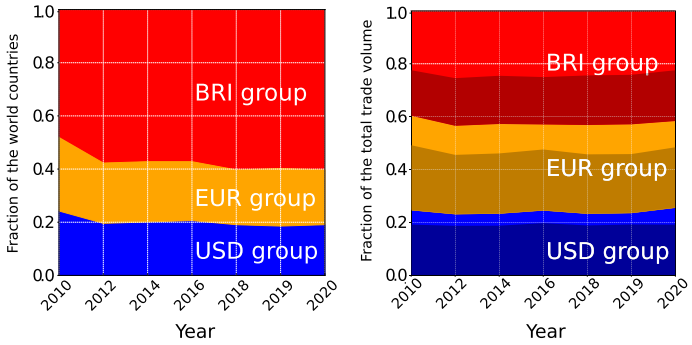

Fig. 3 Evolution of the size of the trade currency groups with time. The height of each band corresponds to the corresponding fraction of world countries (left panel) and to the corresponding fraction of the total trade volume (right panel). The group of countries preferring to trade in USD is colored in blue, EUR in gold, and BRI in red. In the right panel, the fractions of the total trade volume associated to the currency seed groups are shown: Anglo-Saxon group (dark blue), the EU9 group (dark gold), BRICS countries (dark red)

Overall, as shown in Fig. 6 in appendix, the distributions Z_{USD} and Z_{EUR} mainly monotonously decrease with the value of Z_{USD} and Z_{EUR}, respectively. From 2010 to 2019, the lowest range, i.e., $0 < Z_{\mathrm{USD}}, Z_{\mathrm{EUR}} < 0.2$, for both distributions, has even increased, and we note that, for both years, no country has a $Z_{EUR} > 0.8$. This fact corroborates the global decline in the influence of the EUR and USD currencies. On the contrary, the Z_{BRI} distribution is more homogeneous all over the interval [0, 1] with a median which has moved from around $Z_{\mathrm{BRI}} \simeq 0.3$ in 2010 to around $Z_{\mathrm{BRI}} \simeq 0.7$ in 2019 indicating an increase of the global influence of the BRI.

We checked that a modification of the centrality metrics, replacing, in the trade currency scores (1), the countries import–export probabilities P_c and P_c^* by the countries PageRank and CheiRank probabilities obtained from the WTN Google matrix (Coquidé et al. 2019, 2023), leads practically to the same results (compare Fig. 7 with Fig. 1, the sole differences concern modest size countries, the most visible difference is Suriname which in 2019 has a BRI TCP with the WTN Google matrix and a USD TCP with the present model).

In Fig. 3, we show the evolution of the fractions of countries preferring to trade in USD, EUR, and BRI from 2010 to 2020. In 2020, the BRI group captures 60% of the world countries, the EUR group 21% and the USD group 19%. However, the trade volume of the BRI group countries still remains less than 50% being 42%, with 33% for the EUR group and 25% for the USD group. In fact, the fractions of the international trade volume associated to the USD group and to the EUR group are mainly due to the trade exchanges between developed economies within the Anglo-Saxon group and the EU9 group, respectively (see dark colored bands in Fig. 3 right panel). Also, more than half of the trade volume associated with the BRI group is generated by non-BRICS countries, underlining the fact that the BRI currency is able to influence much more widely than just the BRICS countries, unlike the EUR and USD groups which have little influence beyond their areas of regional and historical influence.

Discussion

In this work, we analyzed the competition of three currencies, BRI, EUR and USD, within the international trade. We remind that the BRI currency is supposed to be a new currency pegged to the BRICS countries and proposed recently (Leahy and Lockett 2023; Yeh 2023). For this analysis, we constructed the WTN for years 2010–2020 from the UN Comtrade database (United Nations Statistics Division 2023). As BRI is supported by BRICS, we assume that a group of Anglo-Saxon countries and the EU9 group support the USD and the EUR currencies, respectively.

Our results obtained from Ising type Monte Carlo extensive numerical simulations show that, the influence of each one of the different currencies is well established in their natural zone of influence. The EUR influence is mainly located in Europe and around the Mediterranean sea. The USD influence concerns the Anglo-Saxon countries (North America, UK, Australia and New Zealand) but also contiguous regions as Central America and the northern of South America. The BRI influence spans over Asia and South America on countries which have strong ties with of Brazilian, Russian, Indian and Chinese economies. While the African continent is fragmented in 2010 between the influence of the three currencies, in 2019 almost all African countries (with the exception of Morocco and Tunisia which have strong historical and economical ties with France) are come under the influence of the BRI. This transition is already well underway in 2012 (see Fig. 5). In 2020, 60% of the countries have a structural trade preference for BRI, 21% for EUR, and 19% for USD. The zone of BRI influence spans from the extended geographical diagonal, from South America to Bering strait and passing by Africa. It encompasses the vast majority of developing and least developed countries. Analogously to the Oresme–Copernicus–Gresham law (Balch 1908; Oresme 1365; Copernicus 1526), which states that among two moneys with the same face value the less precious money will drive out the most precious one, the currencies pegged to strong economies, i.e., USD and EUR, are pushed out from the trade of the less developed countries by the BRICS currency which is supported by weaker economies. The loss of influence of the USD and the EUR echoes the loss of influence of the economies of the Western world which remain confined to their historical zone of influence. Moreover, some eurozone countries and others geographically close to it, and historically linked to the EUR, are on the verge of falling under the influence of the other two currencies with a strong tropism for the BRI.

Based on the mathematical analysis of the trade currency preference of the countries, taking account of solely the structure of the WTN and disregarding finer geopolitical considerations, our results show that the influence of the BRICS countries on international trade is now significant and opens the way to a possible prospect of domination of a currency supported by the BRICS development bank at the expense of other global currencies such as USD and EUR.

Appendix

See Figs. 4, 5, 6, 7, and Tables 1, 2, 3.

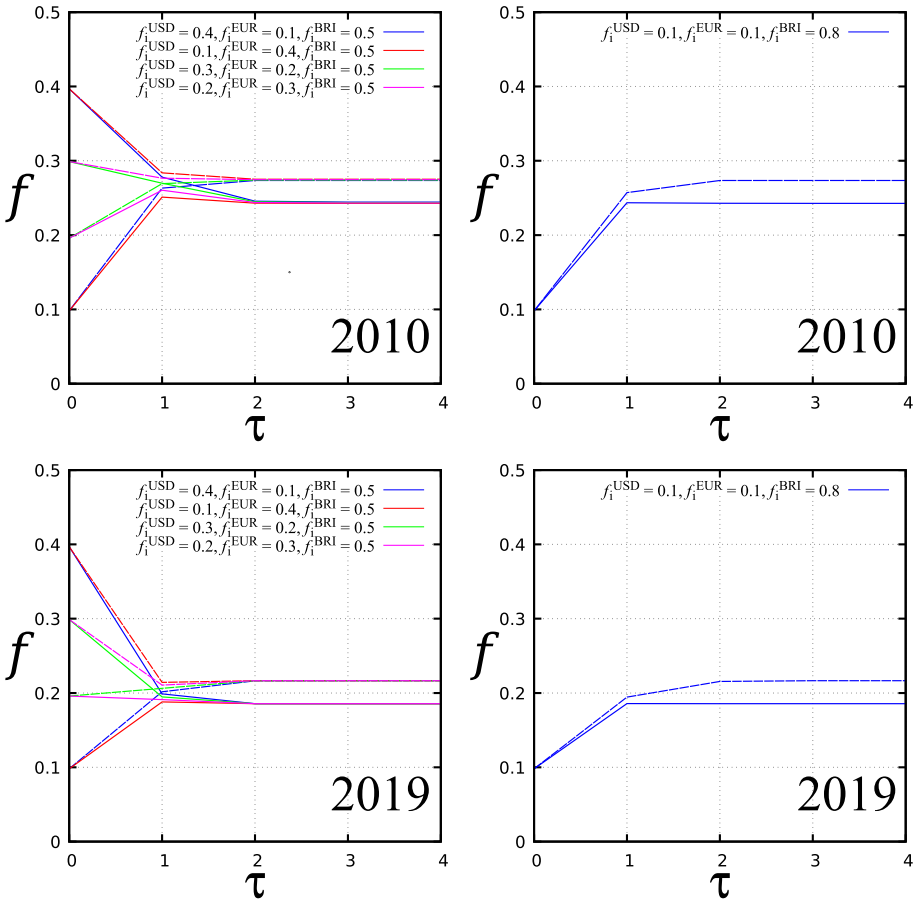

Fig. 4 Examples of evolutions of the fraction f of countries with USD trade preference (f^{USD}, solid line) and EUR trade preference (f^{EUR}, dashed line) as a function of the Monte-Carlo process step τ in 2010 (top panels) and 2019 (bottom panels). The complementary fraction $f^{BRI} = 1 - f^{USD} - f^{EUR}$ gives the fraction of countries with a BRI trade preference. The fractions f are averaged over 10^4 random simulations. In left panels, $f_i^{BRI} = 0.5$, we show four configurations such as $f_i^{USD} + f_i^{EUR} = 0.5$. In right panels, $f_i^{BRI} = 0.8$, we show one configuration such as $f_i^{USD} + f_i^{EUR} = 0.2$. In 2010, the steady state fractions of countries with a USD, EUR, or BRI TCP are $f_f^{USD} = 0.24$, $f_f^{EUR} = 0.27$, and $f_f^{BRI} = 0.49$. In 2019, the steady state fractions of countries with a USD, EUR, or BRI TCP are $f_f^{USD} = 0.19$, $f_f^{EUR} = 0.22$, and $f_f^{BRI} = 0.59$

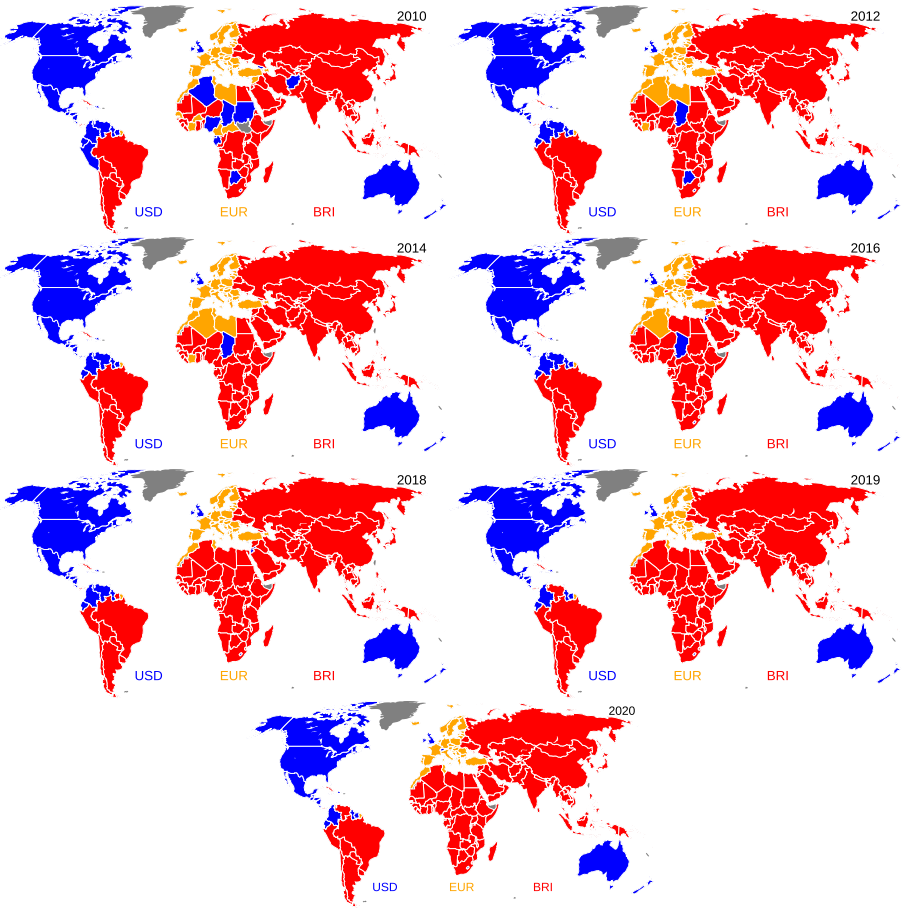

Fig. 5 World distribution of the trade currency preferences for the years 2010, 2012, 2014, 2016, 2018, 2019, and 2020. Countries with a trade preference for USD are colored in blue, for EUR in gold, and for BRI in red. Countries colored in grey have no trade data reported in the UN Comtrade database (United Nations Statistics Division 2023)

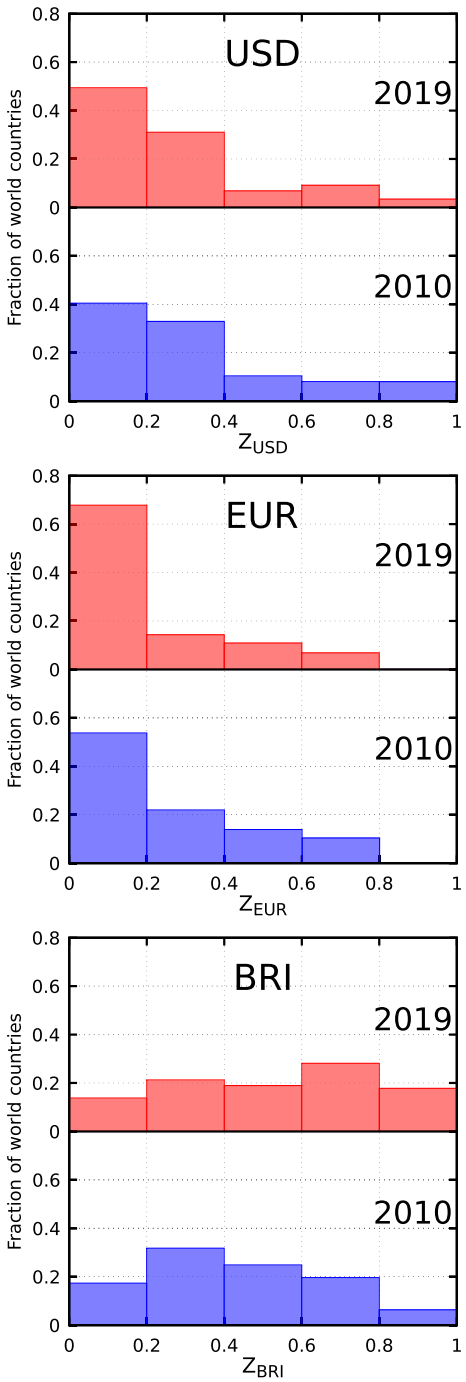

Fig. 6 Distribution of the trade currency scores Z_{USD} (top panel), Z_{EUR} (middle panel), and Z_{BRI} (bottom panel) in 2010 (blue boxes) and 2019 (red boxes). The vertical axis gives the fraction of world countries with Z_c in a given range

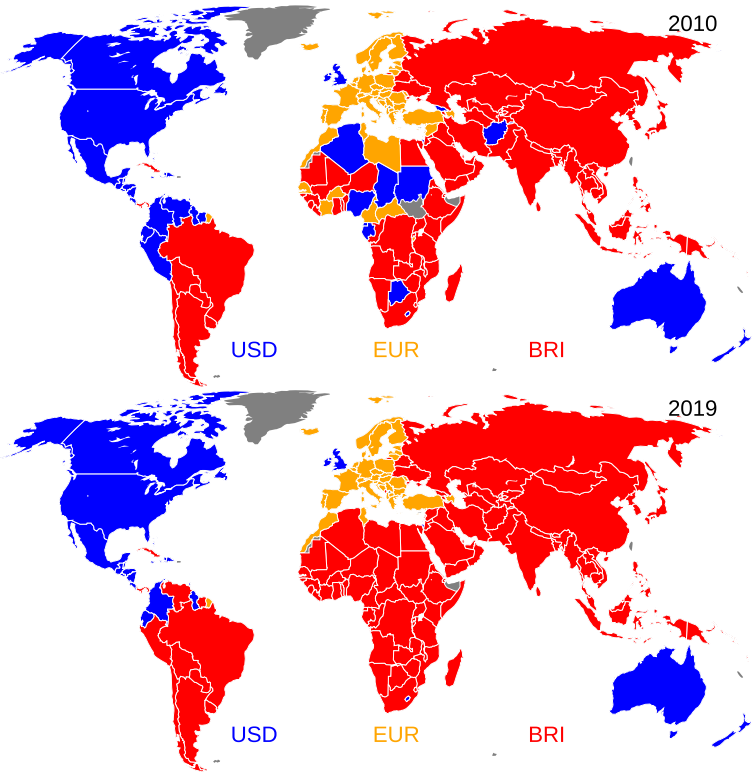

Fig. 7 World distribution of the trade currency preferences for the years 2010 (top panel) and 2019 (bottom panel) when PageRank and CheiRank probabilities, respectively, replace the import and export probabilities, P_c, **and** P_c^*, in the trade currency scores Z_c (1). Countries with a trade preference for USD are colored in blue, for EUR in gold, and for BRI in red. Countries colored in grey have no trade data reported in the UN Comtrade database (United Nations Statistics Division 2023)

Table 1 List of the 36 countries belonging to the USD group in 2019

USD group countries in 2019							
1.	**US**	10.	EC	19.	GY	28.	***AG***
2.	MX	11.	CR	20.	BS	29.	LC
3.	**GB**	12.	GT	21.	HT	30.	VC
4.	**CA**	13.	DO	22.	FJ	31.	KN
5.	**AU**	14.	HN	23.	SR	32.	WS
6.	IE	15.	SV	24.	BB	33.	DM
7.	IL	16.	NI	25.	LS	34.	GD
8.	CO	17.	TT	26.	BZ	35.	***NR***
9.	**NZ**	18.	JM	27.	CW	36.	***TO***

The trade currency preference of these countries is USD at the end of the simulation. The countries are sorted by descending value of $\max\left(P_c, P_c^*\right)$, i.e. the maximum value between the relative import volume P_c and the relative export volume P_c^*, and, in case of tie, by descending value of P_c^*. The bold font countries are the seeds of the USD currency. The bold italics font countries were in the BRI group in 2010. The countries are represented by their ISO2 codes (see Abbreviations)

Table 2 List of the 42 countries belonging to the EUR group in 2019

EUR group countries in 2019							
1.	**DE**	12.	SE	23.	MA	34.	IS
2.	**FR**	13.	HU	24.	LT	35.	CY
3.	**NL**	14.	DK	25.	RS	36.	AL
4.	**IT**	15.	NO	26.	HR	37.	MD
5.	**BE**	16.	SK	27.	**LU**	38.	AD
6.	CH	17.	RO	28.	EE	39.	CV
7.	**ES**	18.	FI	29.	TN	40.	SM
8.	PL	19.	**PT**	30.	LV	41.	ST
9.	CZ	20.	SI	31.	AZ	42.	*PN*
10.	TR	21.	GR	32.	BA		
11.	**AT**	22.	BG	33.	MK		

The trade currency preference of these countries is EUR at the end of the simulation. The countries are sorted by descending value of $\max\left(P_c, P_c^*\right)$, i.e. the maximum value between the relative import volume P_c and the relative export volume P_c^*, and, in case of tie, by descending value of P_c^*. The bold font countries are the seeds of the EUR currency. The italics font country was in the USD group in 2010. The countries are represented by their ISO2 codes (see Abbreviations)

Table 3 List of the 116 countries belonging to the BRI group in 2019

BRI group countries in 2019							
1.	**CN**	30.	PK	59.	MN	88.	*GA*
2.	JP	31.	OM	60.	AM	89.	TJ
3.	KR	32.	KH	61.	BN	90.	SZ
4.	SG	33.	MM	62.	CM	91.	SC
5.	**IN**	34.	GH	63.	*VE*	92.	SY
6.	VN	35.	UZ	64.	MU	93.	ME
7.	**RU**	36.	LK	65.	ZW	94.	NE
8.	AE	37.	LY	66.	ET	95.	SO
9.	MY	38.	BH	67.	BF	96.	SL
10.	TH	39.	JO	68.	TG	97.	KP
11.	**BR**	40.	PY	69.	MR	98.	*GQ*
12.	SA	41.	CI	70.	*AF*	99.	MV
13.	ID	42.	UY	71.	KG	100.	*TD*
14.	**ZA**	43.	MZ	72.	PG	101.	BI
15.	PH	44.	KE	73.	MG	102.	BT
16.	CL	45.	CD	74.	BJ	103.	SS
17.	*NG*	46.	BO	75.	GN	104.	GM
18.	UA	47.	AO	76.	ML	105.	DJ
19.	AR	48.	ZM	77.	CU	106.	SB
20.	IQ	49.	NA	78.	YE	107.	TL
21.	BD	50.	PA	79.	UG	108.	ER
22.	KZ	51.	MT	80.	LR	109.	CF
23.	*PE*	52.	LA	81.	RW	110.	GW
24.	EG	53.	SN	82.	CG	111.	KM
25.	KW	54.	TZ	83.	TM	112.	VU
26.	*DZ*	55.	*BW*	84.	MW	113.	*FM*
27.	QA	56.	*GE*	85.	MH	114.	KI
28.	BY	57.	LB	86.	*PS*	115.	PW
29.	IR	58.	*SD*	87.	NP	116.	TV

The trade currency preference of these countries is BRI at the end of the simulation. The countries are sorted by descending value of $\max\left(P_c, P_c^*\right)$, i.e. the maximum value between the relative import volume P_c and the relative export volume P_c^*, and, in case of tie, by descending value of P_c^*. The bold font countries are the seeds of the BRI currency. The italics (underline) font countries were in the USD (EUR) group in 2010. The countries are represented by their ISO2 codes (see Abbreviations)

Abbreviations

WTN	World trade network
CTP	Currency trade preference
BRICS	Brazil, Russia, India, China, South Africa
UN	United Nations
USD	US dollar
CNY	Chinese yuan
BRL	Brazilian real
EUR	Euro
BRI	BRICS currency
EU	Eurozone
RUR	Russian ruble
INR	Indian rupee
ZAR	South African rand
COMECON	Council for Mutual Economic Assistance
ISO 3166-1 alpha-2 code for countries	:
AF	Afghanistan
AL	Albania
DZ	Algeria
AS	American Samoa
AD	Andorra
AO	Angola
AI	Anguilla
AQ	Antarctica
AG	Antigua and Barbuda
AR	Argentina
AM	Armenia
AW	Aruba
AU	Australia
AT	Austria
AZ	Azerbaijan
BS	The Bahamas
BH	Bahrain
BD	Bangladesh
BB	Barbados
BY	Belarus
BE	Belgium
BZ	Belize
BJ	Benin
BM	Bermuda
BT	Bhutan
BO	Bolivia
BA	Bosnia and Herzegovina
BW	Botswana
BV	Bouvet Island
IO	British Indian Ocean Territory
VG	British Virgin Islands
BR	Brazil
BN	Brunei
BG	Bulgaria
BF	Burkina Faso
BI	Burundi
KH	Cambodia
CM	Cameroon
CA	Canada
CV	Cape Verde
KY	Cayman Islands
CF	Central African Republic
TD	Chad
CL	Chile
CN	China
CX	Christmas Island
CC	Cocos (Keeling) Islands
CO	Colombia
KM	Comoros
CG	Republic of the Congo
CK	Cook Islands
CR	Costa Rica
CI	Ivory Coast
HR	Croatia
CU	Cuba

CY	Cyprus
CZ	Czech Republic
KP	North Korea
CD	Democratic Republic of the Congo
DK	Denmark
DJ	Djibouti
DM	Dominica
DO	Dominican Republic
EC	Ecuador
EG	Egypt
SV	El Salvador
GQ	Equatorial Guinea
ER	Eritrea
EE	Estonia
ET	Ethiopia
FO	Faroe Islands
FK	Falkland Islands
FJ	Fiji
FI	Finland
FR	France
PF	French Polynesia
FM	Micronesia
GA	Gabon
GM	The Gambia
GE	Georgia
DE	Germany
GH	Ghana
GI	Gibraltar
GR	Greece
GL	Greenland
GD	Grenada
GU	Guam
GT	Guatemala
GN	Guinea
GW	Guinea-Bissau
GY	Guyana
HT	Haiti
HM	Heard Island and McDonald Islands
VA	Vatican
HN	Honduras
HU	Hungary
IS	Iceland
IN	India
ID	Indonesia
IR	Iran
IQ	Iraq
IE	Ireland
IL	Israel
IT	Italy
JM	Jamaica
JP	Japan Ryukyu Island
JO	Jordan
KZ	Kazakhstan
KE	Kenya
KI	Kiribati
KW	Kuwait
KG	Kyrgyzstan
LA	Laos
LV	Latvia
LB	Lebanon
LS	Lesotho
LR	Liberia
LY	Libya
LT	Lithuania
LU	Luxembourg
MG	Madagascar
MW	Malawi
MY	Malaysia
MV	Maldives
ML	Mali
MT	Malta

MH	Marshall Islands
MR	Mauritania
MU	Mauritius
YT	Mayotte
MX	Mexico
MN	Mongolia
ME	Montenegro
MS	Montserrat
MA	Morocco
MZ	Mozambique
MM	Myanmar
MP	Northern Mariana Islands
NA	Namibia
NR	Nauru
NP	Nepal
AN	Netherlands Antilles
NL	Netherlands
NC	New Caledonia
NZ	New Zealand
NI	Nicaragua
NE	Niger
NG	Nigeria
NU	Niue
NF	Norfolk Islands
NO	Norway
PS	State of Palestine
OM	Oman
PK	Pakistan
PW	Palau
PA	Panama
PG	Papua New Guinea
PY	Paraguay
PE	Peru
PH	Philippines
PN	Pitcairn
PL	Poland
PT	Portugal
QA	Qatar
KR	South Korea
MD	Moldova
RO	Romania
RU	Russia
RW	Rwanda
SH	Saint Helena
KN	Saint Kitts and Nevis
LC	Saint Lucia
PM	Saint Pierre and Miquelon
VC	Saint Vincent and the Grenadines
WS	Samoa
SM	San Marino
ST	Sao Tome and Principe
SA	Saudi Arabia
SN	Senegal
RS	Serbia
SC	Seychelles
SL	Sierra Leone
SG	Singapore
SK	Slovakia
SI	Slovenia
SB	Solomon Islands
SO	Somalia
ZA	South Africa
GS	South Georgia and the South Sandwich Islands
ES	Spain
LK	Sri Lanka
SD	Sudan
SR	Suriname
SZ	Swaziland
SE	Sweden
CH	Switzerland
SY	Syria

TJ	Tajikistan
MK	Macedonia
TH	Thailand
TL	Timor-Leste
TG	Togo
TK	Tokelau
TO	Tonga
TT	Trinidad and Tobago
TN	Tunisia
TR	Turkey
TM	Turkmenistan
TC	Turks and Caicos Islands
TV	Tuvalu
UG	Uganda
UA	Ukraine
AE	United Arab Emirates
GB	United Kingdom
TZ	Tanzania
UM	United States Minor Outlying Islands
UY	Uruguay
US	United States
UZ	Uzbekistan
VU	Vanuatu
VE	Venezuela
VN	Vietnam
WF	Wallis and Futuna
EH	Western Sahara
YE	Yemen
ZM	Zambia
ZW	Zimbabwe

Acknowledgements
We thank the UN Statistics Division to grant us a friendly access to the UN Comtrade database.

Author contributions
The authors contributed equally to this work. All authors read and approved the final manuscript.

Funding
This research has been partially supported by the grant NANOX N$$^\circ$$ANR-17-EURE-0009 (project MTDINA) in the frame of the Programme des Investissements d'Avenir, France. This research has also been supported by the Programme Investissements d'Avenir ANR-15-IDEX-0003.

Availability of data and materials
The raw data is available from the UN Comtrade database (United Nations Statistics Division 2023). Additional output data and/or plots of data generated are available upon request.

Declarations

Competing interests
The authors declare that they have no competing interests.

Received: 28 April 2023 Accepted: 30 August 2023
Published online: 19 September 2023

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