

# Currency Competition: Currency Internationalization Potential Assessment Using Fuzzy Logic Approach

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## Abstract

Frequently noted inadequately explored connections between currency internationalization and expected change in the polarity of the international monetary system in the international relations literature are commanding the renewed attention and vigorous debate for more international monetary arena studies. This paper examines the potential of competing currencies to internationalize. For the first time, we utilize a fuzzy logic-based multi-dimensional model assessing the internationalization potential of 14 competing currencies separately in 2020 to predict whether the international monetary system is likely to remain unipolar and U.S. dollar-based or evolve into a multipolar international monetary arena. The results suggest comparable levels of currency internationalization exist, indicating that the international monetary system may be further shaped into a more competitive (multipolar) monetary environment, controlling for economic, convertibility, monetary stability, political and legal factors. Finally, our results have policy implications since determined currency internationalization potential levels may facilitate economists and policymakers better understanding of which currencies may play an increasingly large role in becoming a dominant international currency in the international monetary system.

## Keywords

Currency internationalization, Competition, International monetary system, Fuzzy logic, Multi-polarity

## JEL Classification

F31, F33, F63

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## Introduction

Currency systems make it easier to interchange goods and money. To maintain an orderly system of payments among nations, a good-quality international monetary system (hereafter IMS) has to provide international currency services to avoid external real and financial imbalances across countries (Constâncio, 2011). The term currency internationalization has been used to describe a process in which a national currency gains a global role as the main medium of exchange, the unit of account, and the store of value, as a result of significant demands from foreigners, either through international trade or investment (e.g., Chey, 2013, Cohen & Benney, 2013; He & Yu, 2016; Angrik, 2018; Liu et al., 2018; Germain, 2020).

Since World War II, the U.S. dollar has fulfilled these essential responsibilities of a national currency as the dominant world economy's international currency under the current monopolar IMS (He and Yu, 2016). Since private sector transactions are frequently denominated in internationalized currency, most commodities are now priced and sold on commodity markets in U.S. dollars. Because of economies of scale and network externalities, using a single global currency as a natural monopoly is more likely to be perceived as more effective (Chinn & Frankel, 2008). However, it also runs the risk of the Triffin dilemma, according to which the international monetary system's fundamental instability (see, e.g., Farhi & Maggiori, 2018) may lead to asymmetries.

As global economic development and financial assets become more extensively diversified, this system has persisted for half a century underpinning its two main aims, namely solid economic development and cross-border

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goods and capital flows (Eichengreen, 2011; IMF, 2011; Chey, 2013; Lu & Liu, 2020). Prior research favored commonly dollar-centered IMS forecasts until the dollar's future appeared to be less certain recently because, unlike in the past, there are viable alternatives, most notably the Euro (Chey, 2013). However, the dispute about the dollar's role as the world's reserve currency is not new. It dates back to the 1960s when the Bretton Woods system's long-term stability was called into doubt and has resurfaced nearly every time the dollar has lost significant value (Chey, 2013). As several fiat currencies, namely the Euro, the Japanese yen, and China's RMB, have significantly increased their shares in international transactions (Lu & Liu, 2020) along with an increase in various symptoms of IMS instability (e.g., frequent crises, volatile capital flows, and currencies, unprecedentedly large reserve accumulation, persistent current account imbalances), politicians, economists, and journalists, as well as members of the general public, have recently been fascinated by the future shape of the international currency system (Genberg, 2009; Constâncio, 2011; IMF, 2011; Cohen & Benney, 2013; Marginean, & Ora, 2013; Hoffman et al. 2020). Given that polarity is a widely accepted crude measure of the level of competition in any political or economic system (Cohen & Benney, 2013), it would be sensible for a broad audience interested in economic policy issues to ask: does another national currency or currencies have the potential to become a major international currency?

Seeing currency internationalization as a competition between currencies (Genberg, 2009; Hoffman et al., 2020), there is an ongoing call for more currency internationalization studies that can add to the current currency competition debates if a few currencies were to become equally dominant international currencies. Internationalization of national currency is further commonly a significant objective of central banks as it promotes the national financial sector, improves the funding efficiency of financial institutions, and greatly increases international competitiveness (Tagaki, 2011). However, the size of the economy, financial openness, and nature of geopolitical and legal systems underpin/undermine such ambitions (Constâncio, 2011; Hoffman et al., 2020). As a key feature of the international monetary order, the international standings of currencies further impact the economic and political connections between nations and, therefore, define the world economic and political system (Chey, 2013). The calls for more international currency studies are recently accelerated by a new China's industrial policy (China Standards 2035) on the horizon, attempting to build a complete alternative to the dollar system and impact financial infrastructure globally even before the Renminbi is fully internationalized (Hoffman et al., 2020). So far, the debate in the post-crisis and COVID-19 pandemic reconstruction era on the transition to a more multicurrency (multipolar) system, where multiple international currencies play a vital and comparable role globally, making IMS more competitive, suggests little consensus (Mohan et al., 2013, Chey, 2013, Farhi & Maggiori, 2018, Sadil & Sipko, 2021).

Various papers have attempted to explore the drivers of currency internationalization since the GFC, beginning with Goldberg and Tile (2008) examining factors that impact the usage of certain currencies in cross-border trade transactions. According to Chey (2013), the evidence on currency internationalization drivers is mixed as theoretical perspectives on it differ, and determining the relevance of specific determinants of monetary internationalization remains a knowledge gap. Despite few studies investigating currency internationalization levels predominantly by econometric models (e.g., Li & Zhang, 2017; Liu et al., 2018), there is minimal evidence on the level of currency internationalization of systematically important currencies using alternative approaches such as fuzzy logic models. This paper aims to shed more light on prior mixed results stemming from the predominantly econometric approach-based currency internationalization literature. We contrast these studies with an alternative, unconventional approach to assess the level of currency internationalization potential. The main research goal of this study is to determine the internationalization potential levels of currently competing 14 fiat currencies to help economists and policymakers better understand which of them may play an increasingly large role in becoming a dominant international currency in the international financial system. Specifically, to assess whether the euro and the Chinese renminbi, as the widely considered U.S. dollar's main competitors in the IMS, are reaching comparable levels of currency internationalization as the greenback.

We contribute to currency internationalization research in a variety of ways. First, we explore the vital drivers of currency internationalization and classify them within four key dimensions. Second, to the best of our knowledge, this paper proposes the first alternative fuzzy logic model for the recent currency internationalization potential level assessment (namely, for the Australian dollar, Brazilian real, British pound, Canadian dollar, China's RMB, Euro, Indian rupee, Japanese yen, Korean won, Mexican peso, Russian ruble, Swedish crown, Swiss franc, and U.S. dollar). These competing currencies were selected mainly for their value's average daily turnover constituting 91 percent of the foreign exchange market transactions globally (BIS, 2021). Third, we identified controlling for economic, financial, monetary stability, political, and legal factors in line with Cohen (2015), that the U.S. dollar currently has the greatest internationalization potential. Furthermore, we observed the high potential of a few leading F.X. currencies to transform the IMS into a more competitive (multipolar) environment. Our findings have implications for policymakers and academics.

Following this introduction, Section 2 covers the theoretical framework and research questions. Section 3 describes the data sample and methods, while Sections 4 and 5 present the empirical findings and concluding remarks.

## Literature Review

International currency is a currency used beyond its home country (Chey, 2013). More specifically, when currency circulates outside of its issuing country, it becomes international, and if used by non-residents, it advances to vehicle currency status (Liu et al., 2018). If a currency is widely used in financial transactions (by exporters, importers, borrowers, lenders, or currency dealers), it is more likely to be used to invoice financial transactions and to be used as a vehicle currency in foreign exchange trading (Chinn & Frankel, 2008). Cohen (2015) states that internationalized currency brings advantages (minting, transaction costs, macroeconomic flexibility, and political leverage and prestige) but also disadvantages (risk of currency appreciation and political responsibility) to its issuing country, and its willingness to provide global liquidity is, therefore, part of the issuing country's international policy. The decision of the issuing country on whether to support or oppose the internationalization of its currency depends significantly on various macroeconomic and political factors at both the domestic and international levels.

The currency internationalization level commonly refers to foreign economic entities' willingness (demand) to trade, borrow, and invest in a currency other than their home currency (Kenen, 2011; Cohen, 2015). Cohen (2015) highlights that whether a currency becomes internationalized depends ultimately on the willingness of foreign agents to hold it and use it; that is, currency internationalization is predominantly a market phenomenon, reflecting the preferences of diverse actors in global trade and finance. Despite the lack of a widely agreed conceptual framework of IMS (Farhi & Maggiori, 2018), a sizeable amount of research (e.g., Liu et al., 2018; Hoffman et al., 2020) has been conducted on factors that might explain international currency standing. Among the many factors studied are economic, financial, political, and legal aspects. In general, prior research on currency internationalization has recognized two well-anchored approaches (functional and political economy).

### *Functional approach*

The functional approach assumes that the international currency serves three essential currency functions in the private and official sectors (namely the mean of payment, the unit of account, and the store of value) (Kenen, 1983). The functional approach recognizes six uses of a currency as an international currency, namely in the private sector (as a unit of account used in invoicing merchandise trade, as the mean of payment serves as the vehicle currency in F.X. markets, and as a store of value used as a currency in which deposits, loans, and bonds are denominated), and official sector (as the unit of account used in defining parties, as means of payment serves as an intervention currency in F.X. markets, and as a store of value used as a currency in which reserves are held) (Kenen, 1983, Cohen, 2015). The internationalization of currencies increases the usefulness of money in all their private and official monetary functions. Internationalized currencies are commonly held as reserve currencies or used as safe assets. Once a currency is widely used by private entities internationally, it is more likely to be used by central banks and governments as a reserve currency, an intervention currency, and an exchange rate anchor (Cohen, 2015).

### *Political economy approach*

The second approach to currency internationalization is based on political economics and explains how a currency's international standing is connected to the country's economic and political conditions (e.g., Strange, 1971; Chey, 2013). As the economic and political system underpins the ambitions of central banks to internationalize national currencies, the role of economic influence, geopolitical influence, and political stability should not be overlooked (Constâncio, 2011; Hoffman et al., 2020). From an economic and political standpoint, this approach makes it easier to comprehend why a government might accept an internationalized currency administered and controlled by another country and the policy consequences. Regarding prior literature on international currencies using the political economy approach, a currency must meet several requirements to become internationalized, which we briefly review to establish the groundwork for our analytical framework.

International studies have acknowledged the significance of integrating economic and political elements of international relations research, mainly beginning with the study of Strange (1971), calling for more hybrid international political economy studies. According to Chey (2013), the substantial insight on international currency standing begins with Strange's (1971) typology of international currencies, which provides a valuable framework for analysing the impact of legal political (Strange, 1971; Posen, 2008; Subramanian, 2011; Lyratzakis, 2014; Cohen, 2015; McNally, 2015; Liu et al., 2018) and economic factors on the status of international currencies. The currency internationalization determinants from the economic perspective can be further categorized into main three dimensions, namely economic development (Chinn & Frankel, 2008; Chen & Peng, 2010; Kenen, 2011; Maziad et al., 2011; Subramanian, 2011; Mohan et al., 2013; Cohen, 2015), monetary stability (Chen & Peng, 2010; Dincer & Eichengreen, 2013; Mohan et al., 2013; Li & Zhang, 2017), and financial openness dimensions (e.g., Chinn & Frankel, 2008; Kenen, 2011; Maziad et al., 2011; Mohan et al., 2013; Li & Zhang, 2017).

### *Economic and Financial Perspective*

As prior research suggests, the dominant internationalized currency has been throughout the entire history that one of an economically leading country (Eichengreen, 2019), implying the currency internationalization status is linked with economic factors (Chey, 2013; Li & Zhang, 2017). Thus, country economic development is one of the

commonly explored dimensions of currency internationalization (Kiyotaki, Wright, 1989, Eichengreen & Frankel, 1996; Mohan et al., 2013; Cohen, 2015, Liu et al., 2018).

Because the economic dimension is viewed as a driver of demand (attractiveness) of a currency by foreign economic subjects in international currency relations (Mohan et al., 2013), it has piqued the interest of several prior studies (e.g., Kiyotaki & Wright, 1989; Cohen, 2015). Various papers found a positive linkage between economic size (measured by gross domestic product) and the international status of its currency (e.g., Eichengreen & Frankel, 1999; Chinn & Frankel, 2008; Maziad et al., 2011; Mohan et al., 2013; Li & Zhang, 2017), suggesting that as economic growth slows, the process of currency internationalization ceteris paribus will also slow down (Li & Zhang, 2017). Further, the economy's trustworthiness is commonly assessed by credit ratings taking a number of qualitative and quantitative factors into account (Maziad et al., 2011; Mohan et al., 2013). According to Liu et al. (2018), economic integration and stable macroeconomic conditions have a beneficial impact on currency internationalization. On the other hand, high external debt is widely seen as a barrier to currency internationalization since it lowers the issuing country's reputation (Kenen, 2011; Maziad et al., 2011; Cohen, 2015). The internationalization status of a currency has also been found to be influenced by a country's engagement in international trade (Chinn & Frankel, 2008; Maziad et al., 2011; Mohan et al., 2013, Liu et al., 2017). According to Liu et al. (2017), merchandise trade increases the intensity of a global currency. Furthermore, if an economy's export composition is more varied while maintaining high competitiveness (Chen & Peng, 2010), it is more likely to rely on its own currency in international monetary transactions, resulting in economies of scale (Genberg, 2009; Kenen, 2011). Subramanian (2011) further explored factors affecting the composition of the global reserve currency stock and found that the share of world production and world trade significantly affect the importance of a given currency as a reserve currency. His results show that the net investment position has then a weaker effect on the composition of monetary reserves and that the share of world trade plays a more important role than the economy's relative size (Subramanian, 2011). Nevertheless, despite trade and financial interactions increasing the network of currency users, it is noteworthy that currency status is influenced not just by economic and financial conditions but also by "inertia" in currency use due to network externalities and economies of scale and scope (Chinn & Frankel, 2008).

Monetary stability is the second recognized monetary internationalization dimension. The value of a currency shall be stable to be used globally, as currency value instability increases the risk of holding it and reduces its function as a store of value. As a result, stability is a fundamental requirement of the IMS. As increasing inflation rate has been linked to a decrease in the predictability and effectiveness of corporate planning, as well as in the purchasing power of savings and foreign exchange reserves, monetary stability is a widely accepted fundamental necessity of the IMS (Chen & Peng, 2010; Maziad et al., 2011; Mohan et al., 2013). A well-functioning stable IMS helps to keep the value of credit and obligation connections constant. As all prior historical forms of the IMS suggest, there must be confidence in the currency's future value in the initial phase of its cross-border use (Lothian & Dwyer, 2003). Fundamental and purely speculative indicators may be used to gauge confidence in the currency's future value, according to Chey (2013). From the perspective of monetary stability, the inflation rate (Mohan et al., 2013; Chen & Peng, 2010) the transparency of the central bank generating the world currency are two widely accepted key variables used to assess currency internationalization (Dincer & Eichengreen, 2013).

Third, financial openness (convertibility) has been highlighted as another currency internationalization dimension in prior studies. Financial market openness and liquidity, according to prior literature (see, e.g., Kenen, 2009; Maziad et al., 2011; Chen, 2013), are crucial drivers for decreasing transaction costs and generally in currency internationalization process (Cohen 2015), thus evaluating their depth, breadth, and resilience is critical. Furthermore, financial openness is seen by Kenen (2011) as the most important prerequisite for currency to become internationalized. As narrow spreads between buying and selling foreign exchange rates are the result of sufficient trade and competitiveness in financial markets (commonly assessed by financial markets development indices) often directly proportionate to the currency's liquidity (Maziad et al., 2011; Mohan et al., 2013), certain currencies may be divided into three groups based on liquidity status (namely, major, minor, and exotic currencies). Another essential driver of currency internationalization from financial openness perspective is the currency's full convertibility, which is linked to the openness of the capital account of the balance of payments (Maziad et al., 2011; Mohan et al., 2013). The currency's exchange rate regime is also essential (Maziad et al., 2011; Mohan et al., 2013). Countries with a fixed exchange rate arrangement tend to have lower financial openness (Chinn & Ito, 2008). A fixed currency arrangement is often associated with a soft/hard peg to a major currency, such as the U.S. dollar or the Euro in the current international monetary system.

#### *Political - legal perspective*

The political-legal perspective, which includes non-economic factors, is the last but not least examined currency internationalization dimension in this article. As history has shown (for example, in the case of the U.S. dollar or the British pound), this dimension is critical for currency internationalization. The role of the U.S. dollar in international monetary relations did not considerably rise until the Federal Reserve was established in 1913. However, political support cannot in itself be the sole political reason why some currencies achieve world currency status (Eichengreen, 2019).

As transactions in currencies of issuing countries which are characterized by distrust and non-compliance with contractual rules, non-property rights, or the rule of law, are naturally riskier, the level of the legal framework (Cohen, 2015; Liu et al., 2018) and political stability (Cohen, 2015) are vital to be considered when assessing currency internationalization. As market participants are unlikely to be attracted by a country's national currency that does not have sufficient capacity to carry out successful national finance management or has a high level of corruption (Cohen, 2015). Also, a country that issues a world currency should have a sufficient level of military power (Posen, 2008). The more a country's political strength and influence outside its boundaries, the more probable it is that other nations will use its currency (Cohen, 2015). Finally, according to Subramanian (2011), currency inclusion in the SDR currency basket is connected to political prestige and institutional advantages, such as IMF voting rights. It is seen as having a positive influence on currency internationalization because it strengthens the official store of value's role (foreign exchange reserves).

## Methods

The fuzzy logic model examines the potential of 14 fiat currencies to internationalize and transform the currently monopolar IMS into the multipolar arena in the future. According to Mohan et al. (2013), the currency internationalization potential is defined as the ability of a fiat currency to emerge as a reserve currency. Tab. 1 shows the explanatory country characteristics for the model, which were chosen based on previously examined currency internationalization research and sourced from publicly available sources. The data used to calculate the internationalization potential using a fuzzy logic approach are also described in Table 1.

In creating the proposed model of currency internationalization, we were inspired by fuzzy-logic models, applying them in evaluating the potential of a specific country concerning business, presented by Dlouhý (2016) and Dostál (2015; 2017). A detailed introduction and the actual concept of fuzzy logic and fuzzy-logic models are presented by Dostál (2015), Klir and Yuan (1995), and, in an earlier study, also by Zadeh (1965). Compared with econometric models, the advantage of fuzzy-logic models lies in their robustness, tolerance to value and noise errors, and relatively easy application. By contrast, a disadvantage may be lower accuracy.

As Tab. 3 illustrates, the output of the fuzzy-logic model used is the I parameter, representing the potential of currency internationalization. This parameter can take on the value of 0 to 1, or, more precisely, 0–100 %. A currency, the internationalization potential of which is close to 0, cannot fulfil the role of reserve currency, while within the international monetary system, a currency with the highest value of I constitutes a world reserve currency. By comparing the I parameters of the 14 most important currencies of developed countries and BRIC group countries, the current competitive position in the context of currency internationalization can be determined.

**Table 1.** Summary of variable definitions, measures, and sources.

Variable	Definition and measures	Sources
Panel A: Dependent variables: Currency internationalization potential		
	Internationalization potential is the potential of fiat currency to emerge as a reserve currency.	Mohan et al. (2013)
Panel B: Explanatory variables: Country characteristics (economic development, monetary stability, financial openness, legal and political system)		
Economic dimensions		
E.P.	Economic position within the world economy measured as the percentage share in world GDP at PPP exchange rates.	World Economic Outlook Database, IMF (2021a)
ET	Economic trustworthiness determined by long-term foreign currency credit ratings for sovereign bonds as reported by S&P (S&P sovereign ratings).	S&P (2021)
GTP	Global trade position measured by the percentage share in global exports. The share of world exports equals the exports of a particular country as a percent of the total exports of all countries worldwide.	WTO (2021)
EEP	The external economic position is proxied by the net international investment position (NIIP) as a percentage of GDP. The calculations are based on the difference between the external financial assets and liabilities of a country as defined in the 6th Edition of the Balance of Payments Manual (BPM6).	World Economic Outlook Database, IMF (2021a)
DI	The IMF export diversification index assesses the diversification of exports, which provides information on a country's export quality. Higher index values correspond to lower country's export diversification.	IMF (2017)
GC	Competitiveness within the world economy is measured by the World Economic Forum global competitiveness index 4.0, which aggregates 103 indicators anchored in growth accounting economic literature.	Schwab (2019)

ED	External debt measured as general government gross debt as a percentage share of GDP. Debt is computed as the sum of the following liability categories (as applicable): currency and deposits; debt securities, loans; insurance, pensions, standardized guarantee schemes, and other accounts payable.	World Outlook IMF (2021a)	Economic Database,
Monetary stability dimensions			
CPI	Price stability, measured by the inflation rate as the annual percentage change, is proxied by 10Y average consumer price index (2010=100) tracking the country's average level of prices based on the cost of a typical basket of consumer goods and services.	World Outlook IMF (2021a)	Economic Database,
CBT	Central bank transparency, measured by the sum of the scores for answers to the fifteen transparency-related questions w (min = 0, max = 15).	Dincer and Eichengreen (2013)	
Financial openness dimensions			
CAO	Capital account openness, measured by a country's degree of capital account openness, proxied by the Chinn-Ito financial openness normalized (KAOPEN), which is based on the binary dummy variables to codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER).	Chinn and Ito (2006, 2018)	
FMO	The Financial Market Openness Index is the unweighted average of the openness of twelve asset categories: equity, bond, money market, collective investment, derivatives, and other instruments. It ranges between 0 to 1 (1 indicates fully liberalized).	IMF (2016a)	
FMD	Financial market development, measured by the financial development index, is a relative ranking of countries on their financial institutions and financial markets' depth, access, and efficiency. It is an aggregate of the related financial institution index and the financial market index reported by IMF.	IMF Data, (2020b)	IMF
ERA	Exchange rate arrangement of the country determined by IMF exchange rate arrangements classification.	IMF (2020, AEREAR)	
LI	Liquidity status proxied by the F.X. bid-ask spread size (relative to U.S. dollar) to categorize the currency (major, minor, exotic).	Foreign Exchange data (own processing)	
Political and legal dimensions			
P.S.	Political stability measured perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism, proxied by the political stability index reported by the World Bank.	The global economy (2021)	
CL	Level of corruption, measured by corruption perception index, which ranks perceived levels of public sector corruption on a scale of zero to 100, based on experts and business people. Zero is highly corrupt, and 100 is very clean.	Transparency International (2021)	
WJP	Legal level, proxied by the world justice project rule of law index, which evaluates the rule of law adherence as experienced and perceived by legal practitioners and experts, and households.	World justice project (2021)	
P.I.	Military strength, measured by PowerIndex. The smaller value of the index, the more powerful a nation's theoretical fighting capability is.	Global firepower (2021)	
SDR	The share of currency in the SDR basket.	IMF (2016b)	

Note: The definitions and measurements of currency internationalization as a dependent variable and country characteristics as explanatory factors are presented in this table. Each variable's source is also provided. Data with a year-end date closest to 2020 were used for the study.

**Source:** Authors' work

Fuzzy logic is applied in three stages: fuzzification, inference, and defuzzification. The first stage, fuzzification, represents transforming real variables (from Tab. 1) into linguistic variables (see Tab. 2). Based on an expert estimate, vague linguistic variables were defined for each determinant of currency internationalization. This model is partly based on criteria given in the original sources (determinants E.T., DI, CPI, FMD, ERA, CL, WJP), or alternatively, linguistic variables are defined evenly by logic (E.C., EED, E.D., CBT, CAO, FMO, LI, P.S., SDR) as well as by an expert estimate only (GTP, G.C., P.I.). A degree of truth is determined for each linguistic variable, expressed by a membership function. The progression of membership functions can be linear (for ex. CAO), exponential (for ex. E.P.), or A-shaped (for ex. CPI).

The second stage, inference, consists of defining rules such as "if-then-else" at the linguistic level and constructing a transformation matrix. The weight of each rule is crucial for the result from the proposed fuzzy system. Membership function values are determined in accordance with requirements based on an expert estimate (see

square bracket in Tab. 2). The key criterion is the importance of the individual determinants of currency internationalization, which is extremely problematic to determine in a highly complex system. The individual criteria are characterized by different levels of importance for currency internationalization. In total, six parameters (E.P., E.T., GTP, CPI, CAO, FMO) were selected, identified as priority parameters for currency internationalization based on literary research. For these, double weighting was expertly determined, reflected in the transformation matrix structure and parameter I calculation.

The next step of inference is completing a state matrix for a particular currency. At any one time, one output can only have one attribute. Based on the analysis and classification of the input data, membership in a specific parameter is determined for 19 selected parameters (1: yes, 0: no). For the state matrix for 14 selected currencies (see Appendix 1). The calculation within the fuzzy-logic model is then based on a scalar product, as per the following formula (1). MATLAB or similar programming and numeric computing platforms can be used for the calculation.

$$I = 100 * ((\text{SUMPRODUCT}(\text{TM}; \text{SM}) - \text{MIN}) / (\text{MAX} - \text{MIN})), \quad (1)$$

where

I is internationalization potential

TM is transformation Matrix (see Tab. 2)

SM is state Matrix (see Appendix 1)

The third stage of the process is defuzzification, during which the fuzzy inference output (I value) is transformed into real linguistic value. The transformation of the fuzzy value of the output variable should thus correspond as closely as possible to the result of the fuzzy calculation (Dostál 2015). The output I value is analytically compared in the examined currencies (see the Results section). There is room for further research, whereby any currency in the IMS can be classified this way and sorted into different categories in accordance with their currency internationalization potential, for instance, using Cohen's currency pyramid concept (2015).

**Table 2.** Transformation Matrix.

Dimensions		Linguistic/numeric variables		
Economic				
EC	ET	GTP	EED	DI
Very-high share (> 6 %) [20]	Very positive (> +50 %) [10]	Very positive (> +50 %) [10]	Very positive (> +50 %) [10]	Very high diversification (< 2.38) [10]
High share (3-6 %) [12]	Positive (0-50 %) [8]	Positive (0-50 %) [8]	Positive (0-50 %) [8]	High diversification (2.38-3.28 %) [7]
Medium share (0.5-3 %) [4]	Negative (-50-0 %) [6]	Negative (-50-0 %) [6]	Negative (-50-0 %) [6]	Medium diversification (3.28-4.04 %) [5]
Low share (0.1-0.5 %) [2]	Very negative (> -50 %) [4]	Very negative (> -50 %) [4]	Very negative (> -50 %) [4]	Low diversification (4.04-4.77 %) [3]
Very low share (<0.1 %) [1]				Very low diversification (> 4.77) [1]
Economic		Monetary stability		
GC	E.D.	CPI	CBT	
Very high (> 80) [10]	Very high (> 100 %) [1]	Deflation (> -0.5 %) [10]	High transparency (12-15) [10]	
High (70-80) [7]	High (60-80 %) [3]	Very low inflation (0.5-2.5 %) [20]	Rather transparency (8-12) [8]	
Medium (60-70) [3]	Medium (40-60 %) [5]	Low inflation (2.5-7 %) [10]	Average transparency (4-8) [5]	
Low (< 60) [1]	Low (20-40 %) [7]	Medium inflation (7-25 %) [2]	Non-transparent (< 4) [1]	
	Very low (< 20 %) [10]	High inflation (> 25 %) [0]		

## Financial Openness

CAO	FMO	FMD	ERA	LI
Fully opened (0.9-1) [20]	Fully opened (0.8-1) [20]	High degree ( $> 0.64$ ) [10]	Independently floating [10]	Exotic currency ( $> 50$ pips) [1]
Opened (0.6-0.9) [15]	Opened (0.6-0.8) [15]	Medium degree (0.44-0.64) [7]	Managed floating [7]	Minor currency (3-50 pips) [5]
Rather opened (0.4-0.6) [10]	Rather opened (0.4-0.6) [10]	Low degree (0.30-0.44) [3]	Crawling pegs [3]	Major currency (0-3 pips) [10]
Rather closed (0.2-0.4) [5]	Rather closed (0.2-0.4) [5]	Very low degree ( $< 0.30$ ) [1]	Fixed pegs [1]	
Closed (0-0.2) [1]	Closed (0-0.2) [1]			

## Political and legal

P.S.	CL	WJP	PI	SDR
Stability (0.5-2.5) [10]	Very low (90-100 %) [10]	Very high (0.75-1) [10]	Superpower ( $< 0.10$ ) [10]	The highest share (max %) [10]
Rather stability (0.0-0.5) [7]	Relatively low (70-90 %) [7]	High (0.50-0.75) [7]	High power (0.10-0.25) [7]	High share ( $> 10$ %) [5]
Rather instability 0.0-1.0) [3]	Medium (40-70 %) [3]	Medium (0.25-0.50) [3]	Medium power (0.25-0.75) [3]	Minor share ( $< 10$ %) [3]
Instability (-1.0--2.5) [1]	High (0-40 %) [1]	Low (0.0-0.25) [1]	Weak power ( $> 0.75$ ) [1]	No share (0 %) [0]

The values of the membership function are presented in square brackets. The decision criteria for each category are given in parentheses.

Source: Authors' work

## Results

The I-values of the currency internationalization potential are presented in Tab. 3. In total, 14 selected currencies were evaluated. The highest I value is linked to the U.S. dollar (83.0 %), followed by the Euro (81.3 %), Japanese yen (79.1 %), and British pound (75.2 %). Next, come other reserve currencies (Canadian and Australian dollars, Swiss franc) and currencies of highly developed world economies (Swedish krona, Korean won). With its resulting potential of 56.1 %, the Chinese Renminbi shows the highest I value of BRIC group countries. The currency internationalization potential of other countries from this group remains low.

**Table 3.** Fuzzy-Logic Model Output: Internationalization Potential.

Currency	USD	EUR	JPY	GBP	CAD	AUD	SEK	CHF	KRW	CNY	RUB	INR	MXP	BRL
I (2020)	83.0	81.3	79.1	75.2	75.2	70.4	70.4	70.0	63.0	56.1	38.7	33.0	30.4	27.8

Source: Authors' work

The U.S. dollar achieves the highest currency internationalization potential value despite some worsening indicators from the U.S. economy. In particular, these include a significantly negative net investment position, a declining share of GDP in the global economy, and a deterioration in the country's credit rating. On the other hand, the dimensions of monetary stability, financial openness, and political support work in its favour. Moreover, applying 2001 and 2010 data in the fuzzy-logic model results in interesting findings (see Tab. 4).

**Table 4.** Time Comparison of I Potential for USD and CNY.

Currency	USD	CNY
I (2020)	83.0	56.1
I (2010)	88.3	50.9
I (2001)	89.1	29.6

Source: Authors' work



Evidence suggests a weakening of the internationalization potential by more than 6 percent over the past two decades. The weaker performance of the U.S. dollar was caused by deteriorating determinants relating to economic performance.

The I value for the Euro falls behind the U.S. dollar by 1.7 %. The internationalization potential of Euro is supported by comparable determinants as with the U.S. dollar, particularly within the economic performance dimension. However, the higher fragmentation and lower development of financial markets in comparison with the United States (financial dimension) and increasingly insufficient political support for its international role work against the Euro.

Regarding the Chinese Renminbi, its restrictions on the capital account and the closed nature of the financial market work against it. On the contrary, favourable determinants for the Renminbi are economic performance and currency stability. Over the past twenty years, the Chinese Renminbi has almost doubled its internationalization potential (see Tab. 4). If the capital account liberalization, fully openness of financial markets and free floating of renminbi are assumed into the presented fuzzy model, the internationalization potential can increase beyond 70 %. We, therefore, agree with Chen and Peng (2010), who concluded that the current potential of the Renminbi as a reserve currency could lead to it attaining the level of the British pound or Japanese yen.

It is worth comparing the results of the proposed fuzzy model with table 5, which shows the indicators of currency concentration for 6 of the most important world currencies. There exists a strong non-linear relationship between the values of the currency internationalization potential (I) and average currency concentration. The international currency market can be characterized as a market of imperfect competition of a monopolistic or oligopolistic nature. The network and substitution effects strengthen demand for the currency with the highest internationalization potential. Such a currency commonly has the lowest transaction costs, a well-developed trading network, and a developed financial market. The difference in the I parameter for the U.S. dollar and the Euro means almost a 20 % difference in the currency concentration between these currencies. The data provided thus confirm the conclusions about the network effect presented by Cohen (2015).

**Table 5.** Concentration Ratios (values in %).

2020	Forex Turnover	Banking Claims	International Securites	Global Payments	OTC Derivates	Reserves	Average
USD	44.00	45.93	45.57	42.52	50.00	60.46	48.08
EUR	16.00	32.49	38.00	32.06	24.00	20.53	27.18
JPY	8.50	4.59	1.78	3.61	3.00	4.50	4.33
GBP	6.50	3.89	8.30	6.21	8.00	4.50	6.23
CHF	2.50	1.80	0.75	0.98	0.50	0.17	1.12
CNY	2.00	0.50	0.38	2.22	1.00	2.13	1.37

**Source:** Sadil, Sipko (2021) & authors' own calculation

With reference to the research question stated in the introduction, the IMS does not, at present, show a multipolar character with regard to the results found. However, in terms of the long-term trend of the currency internationalization potential development in three of the most important currencies of the expected future architecture of international currency relations (U.S. dollar, Euro, and Chinese Renminbi), a transition to currency multi-polarity can be expected, although not in the near future. Despite a significant strengthening of the currency internationalization potential over the last two decades, the Chinese Renminbi still has a long way to go to reach a comparable level of the internationalization potential of the U.S. dollar and Euro. Where the multipolar currency system is concerned, three or more currencies show corresponding values of currency concentration. At the same time, they should show a corresponding internationalization potential, which has not, however, been established in our research at present. The other currencies analysed show a significantly lower currency internationalization potential than the U.S. dollar and the Euro.

## Conclusion

In the global economy, monetary competition is unavoidable. The current non-system no longer provides stable currency relations due to the significant exchange rate volatility, and adjustments are thus inevitable (Mikita, 2015). The debated race between leading F.X. currencies such as the U.S. dollar, the Euro, and China's Renminbi is widely considered as deeply political, affecting the global power balance and firm competitiveness in a globalized world. Currency internationalization and its drivers are thus significant are among major themes in the international finance literature, and they have a long history of providing many useful insights (Lu & Liu, 2020). However, their research has used mainly econometric models so far, neglecting the alternative fuzzy logic approach. Our study is supposed to contribute also to theoretical rethinking and policy debates on this issue of growing attention.

Building on prior research, we hypothesize 19 factors across four dimensions are influencing currency's internationalization potential. Using the recent country-level data, we determine the currency international potential for 14 fiat currencies across these dimensions. Our unconventional method's strength is further in that it evaluates currency internationalization potential in a unique, multi-dimensional manner. We find the highest internationalization potential in the currently remaining unipolar U.S. dollar-based IMS has the greenback. Our findings controlling for economic, financial, political, and governance factors also show that currently, the Euro, Japanese yen, British pound, Swiss franc, and China's RMB are among the first five greenback fiat currency competitors based on internationalization potential to transform the system into a multipolar one in the future. This finding is consistent with a prior currency internationalization literature (e.g., Chen & Peng, 2010) that finds the U.S. dollar, the Euro, the British pound, the Japanese yen, and the Swiss franc as five leading major currencies. Further, when we examine the internationalization potential of each currency separately, we discover that, while China has been steadily increasing its role in international finance, aspiring to become a major economy (Chen et al., 2009; Lyratzakis, 2014), the Renminbi currently lacks comparable internationalization potential to the currently dominant U.S. dollar. Our results, however, also show that the Chinese RMB has the greatest internationalization value among the BRIC countries. This adds to the growing body of knowledge on the Renminbi's potential as an international currency, the advantages and dangers that come with it, and the appropriate government policies in promoting its growth (He and Li 2005; Li, 2006; Chen & Peng, 2010; Chey, 2013, Li & Zhang, 2017).

Our results might be useful to policymakers in discussions regarding the IMS's future design and in determining if the IMS's key currency competitors are achieving comparable levels of currency internationalization. A theoretical benefit of the proposed model may be a better understanding of current changes in the international monetary system.

This paper identifies some limitations as well as areas for future investigation. One of the article's drawbacks is that it is not designed as longitudinal research. Additional research may be conducted over a longer period to capture the shifting levels of currency internationalization potential together with increased/decreased currency involvement in international transactions (Lu and Liu, 2020), which might facilitate understanding of the IMS's future architecture. Another limitation of the paper is that it uses trade as a proxy for economic dominance. Because of the increasing fragmentation of the value-added chain due to supply chains and outsourcing, this metric may be skewed, resulting in an overestimation of trade and, as a result, trade dominance over time (Subramanian, 2011). The use of relative measurements was utilized to reduce the possibility of distortion. As prior research examined a wide range of economic and political determinants of international currency acceptability, their relative importance, and associated theoretical viewpoints are, however, still debatable (Chey, 2013; Lu and Liu, 2020; Chen and Pan, 2021) as economic and political factors may change over time. Further, future research might look at the influence of additional proxies not included in our model. More particular, we urge academics to look into potential causes that might lead to a shift in the status quo. Future research can reveal whether rising geopolitical tensions will lead to strategic shifts in reserve holdings, whether the COVID-19 pandemic will change the global economic landscape, and whether technological advancements (particularly the emergence of digital currencies) will hasten the transition to alternative, potentially less stable reserve currencies configurations.

Finally, the focuses of further research lie in modifications of the proposed fuzzy model (the input variable, weight of the individual parameters, etc.) and examining the level of the currency internationalization potential in the future. The effects of the current global economic recession on the international monetary structure can only be evaluated with the passage of time. The global COVID-19 pandemic has given rise to major social and economic changes throughout the world economy, which includes the environs of the international monetary system, forming its future character. The model proposed in this study is one way of approaching future evaluation, thus contributing to the discussion concerning one of the most important parts of the global economic system.

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CI	1	0	1	1	0	0	1	0	0	0	0	1	0	1	0
	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1
	0	1	0	0	0	0	0	1	0	1	1	0	1	0	0
LL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	1	1	0	1	1	0	1	0	0	1	0	1	0
	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1
	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0
PI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1
	0	1	0	0	0	1	1	1	1	1	0	0	0	0	0
	1	0	1	1	0	0	0	0	0	0	1	1	0	1	0
SDR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
	1	1	1	1	0	0	0	1	0	1	1	1	1	1	0

Note: The structure of the State Matrix corresponds to Table 2. For example: EC for AUD 0-0-1-0-0 = Medium share.

Source: Authors' work