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GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

Should cryptocurrencies be included in the portfolio of international reserves held by central banks?

Winston Moore^{1*} and Jeremy Stephen¹

Abstract: In most countries, the central bank is required to hold reserve assets as a means of providing credibility for the value of the fiat currency. These assets can be in the form of gold, foreign exchange or some other internationally recognised reserve asset and are held to permit the country to engage in international transactions. Within recent years, cryptocurrencies have been increasingly utilised for international transactions, and it is possible that the use of these cryptocurrencies might expand in the future. This paper therefore examines the potential role of digital currency balances as part of the portfolio of external assets held by a central bank. Using the case of Barbados, the paper also provides a simulation of the effect holding some proportion of their asset-base would have had on the stability of the foreign reserves as well as the return on the portfolio of assets.

Subjects: Econometrics; Finance; International Finance; Macroeconomics

Keywords: international reserves; cryptocurrencies; fixed exchange rate

JEL classifications: F3; E4; E5

1. Introduction

International reserves are external assets held by the monetary authorities for conducting international transactions, intervention in foreign currency market as well as maintaining confidence in the



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PUBLIC INTEREST STATEMENT

Digital currencies, such as Bitcoin, are growing in popularity and are currently being used to facilitate purchases both online and in regular brick and mortar establishments. Countries with fixed exchange rates normally hold a portfolio of balances denominated in various currencies to not only facilitate transactions but also defend the exchange rate peg. Despite this growing popularity of digital currencies, however, very few studies have considered the implications of including digital currency balances in the portfolio of foreign assets held by central banks. This paper therefore examines the potential implications of such balances, using the case of a small open economy that has maintained a fixed exchange rate peg for a relatively long period of time: Barbados. The results of the study would be of use to policy-makers in other small states as well as other developing countries where digital currencies are growing in popularity as a means of completing transactions.

exchange rate (IMF, 2013). These reserves should normally represent some claim on non-residents and be easily convertible to cash, but do not necessarily have to be on a tangible asset (e.g. gold bullion). Besides providing the liquidity to engage in international transactions, Aizenman and Lee (2007) also note that since the 1997/98 East Asian Financial crises, there has also been a shift in the demand for international reserves beyond what is required for transactional purposes. These countries have therefore been hoarding international reserves as a means of providing some degree of self-insurance in the likelihood that the economy is subjected to an economic shock and therefore allow for some adjustment to occur on the balance of payments side (Heller, 1966). It is also possible that by holding stocks of foreign exchange reserves, above what is necessary for transactional purposes, countries can then finance a sudden stop and defend against a speculative attack on the currency (Aizenman & Sun, 2012).

International reserves allow a country to manage its domestic financial stability as well as its exchange rate (Obstfeld, Shambaugh, & Taylor, 2010). In very open financial systems, it is possible for currency mismatches to arise. If this mismatch impacts confidence in the financial system, it could then lead to bank runs and/or capital flight. By acting as the lender of last resort, the central bank, through its holdings of international reserves, can provide liquidity support to banks faced with either scenario. For countries at risk of capital flight, reserve accumulation can enhance confidence in the financial system and reduce the likelihood of shocks to the financial system.

Holdings of international reserves are also associated with the level of development of the financial market. Dominguez (2009) argues that in underdeveloped financial markets, firms may under-insure against the possibility of future credit constraints. In this scenario, sterilised reserve accumulation may be a logical response by the monetary authorities against future financial constraints. Moreover, by sterilising these inflows, this approach to reserve accumulation also provides investment vehicles for the private sector and households, i.e. government paper.

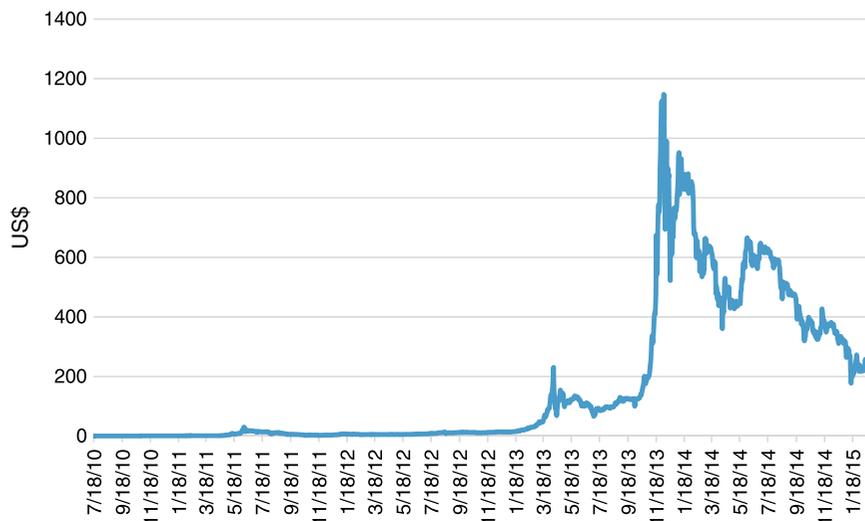
Within the Caribbean, Dehesa, Pineda, and Samuel (2009) utilise the optimal reserve model developed by Jeanne (2007) to investigate the adequacy of reserve levels in the Eastern Caribbean Currency Union. In recent years, the grouping of small countries in the Caribbean has accumulated reserves above traditional metrics of reserve adequacy. Dehesa et al. (2009) argue, nevertheless, that the reserve accumulation that has taken place in these countries appears to be adequate, given the types of shocks that tend to occur in these relatively small open economies. It would, however, be too expensive for these countries to hold enough reserves to offset a 1 in 100 year shock.

Within recent years, internet-based currencies and payment systems have emerged that do not require banks to process payments. The first, and still the largest, of these so-called cryptocurrencies was Bitcoin (Dwyer, 2015; Grinberg, 2011). Unlike most other currencies normally held by the central bank in their international reserves, the supply of cryptocurrencies is not controlled by a central bank but by a highly complex iteration of a mathematical proof. Network users, known as miners, gather blocks of transactions together and vie to verify them. In return, these users receive a new supply of the currency as well as any transaction fees. Several businesses around the world at present accept Bitcoins as a means of final payment.

Over the last four years, the US dollar price of Bitcoin has grown exponentially. After starting in 2010 at just US\$0.09, by 2013, the price of each Bitcoin had risen to US\$1120. Since this peak, however, the price fell to just US\$177 in January but has since rebounded to over US\$250 (Figure 1). In addition to the tremendous rise in price, it has also exhibited a significant degree of volatility.

While the benefits of digital currencies are clear for private individuals and businesses in terms of lower transaction fees and ease of payment, the potential benefits of using digital currencies, as a means shoring up a country's international reserves, remain unexplored. Previous research suggests that the demand for international reserves in Barbados is largely driven by real income, the propensity to import and capital account liberalisation. This paper contributes to the literature on digital

Figure 1. Price of Bitcoin (US\$).



currencies by providing an assessment of the potential benefits and costs of holding Bitcoins as part of the portfolio of international reserves in a fixed exchange rate economy (i.e. Barbados).

The remainder of the paper is structured as follows. Following the introduction, Section 2 of the paper provides a summary of the literature on cryptocurrencies, paying particular attention to the monetary implications of this development. Section 3 of the paper provides a discussion of the methodological approach employed in the study. Section 4 examines the implications for Barbados' international reserves with a view towards making policy recommendations on whether or not the Central Bank of Barbados should consider this means of payment as part of the currency basket. Section 5 of the paper concludes with a summary of the main findings as well as recommendations. These recommendations could be of use for not only the Central Bank of Barbados, but also central banks in other small island states.

2. Literature review

A cryptocurrency is a digital token produced by cryptographic algorithms. This token is then transported across cyberspace using protocols such as peer-to-peer networking. Its value is mainly derived from the demand and supply for such tokens and an important part of their appeal resides in the decentralisation of the system in which they exist. The general discourse on cryptocurrencies has led to varying levels of support for the innovation, where some regulators have been very wary of it while the Financial Technology (Fintech) community have argued about the inevitable widespread use of cryptocurrencies. The main benefits cited are: the security features; ease of use on mobile devices; relatively cheap costs of production and transmission via the Blockchain transmission protocol; and low long-term inflation risks (Harvey, 2015). In fact, global financial corporations, such as Citibank, are developing their own cryptocurrencies due to these perceived benefits of utilising the aforementioned protocols (Madore, 2015). Harvey (2015) also noted that the main issues with the adoption of cryptocurrencies include an early track record of illiquidity, high volatility and potentially nebulous uses. Most of the issues surrounding the successful adoption of cryptocurrencies are marred in the confusion of whether they are digital or virtual currencies, and as such, how their values are determined.

There has been a proliferation of virtual currencies across the globe. These include Facebook Credits, Microsoft Points and Amazon coins. Unlike Bitcoins, as alluded to before, these currencies are issued by companies and are not linked to any claims on real assets. If a large company like Facebook does launch a currency to compete with traditional currencies, network effects could ensure that the currency is taken-up quite quickly by members of the network. Furthermore, Wagner (2014) explained that the value and distribution of virtual currencies are typically controlled by

centralised authority, which is usually the issuing corporation, and are used to solely facilitate online purchases. Digital currencies are closer in form to physical currencies due to their usage as a medium of exchange for physical assets. Ironically, ECB (2012) posits that most of the modern world's money supply is in digital form and, as such, can be considered to be in the form of digital currencies.

Another area of compelling arguments has been the issue of whether digital currencies should be considered to be currencies or digital assets. Given the aforementioned definition, one could expect to view the token as a currency, but Glaser, Zimmermann, Haferkorn, Weber, and Siering (2014) further convey that users of cryptocurrencies are

not interested in an alternate transaction system but seek to participate in an alternative investment vehicle. Drawbaugh and Temple-West (2014) note the US Inland Revenue Service sees cryptocurrencies as a virtual currency and therefore it should be considered to be an asset. Such property, under US financial law, is largely subject to capital asset taxes. Other early adopting jurisdictions, such as Norway, Sweden, and Canada also recognise cryptocurrencies as an asset. However, Germany—also a very early adopter—accepts that cryptocurrencies are a unit of account to be used for trading and taxation within the country but in the form of “private money”

(Clinch, 2013). There has basically been no global consensus on whether to define cryptocurrencies as an asset or currency. These matters have been evaluated within the parameters of every jurisdiction and their capabilities to regulate it.

Given the possibility of a quick take-off, Gans and Halaburda (2013) investigate whether there is a need for regulation and oversight of these digital currencies. The authors argue that most of these digital currencies issued by companies are largely subsidies for buyers to participate in the network or platform (e.g. Amazon coins and Kindle). Such a system is also cheaper for the company, as these currencies have to be spent on items on the platform (e.g. Amazon) rather than some outside good or service. For digital currencies not tied to a particular platform (e.g. Bitcoin), Gans and Halaburda (2013) note that these currencies can impact price stability, financial stability and payment stability and therefore there might be a case for further regulation.

If there is a relatively low level of interaction between these virtual currencies and traditional currencies, however, there might not be a need for any regulatory intervention. There are four potential risks associated with virtual currencies that are of interest to central banks: price stability; financial stability; payment system stability; and lack of regulation and reputation (ECB, 2012). Virtual currencies could make the goal of price stability somewhat difficult if they affect the central bank's control of the money supply through open market operations. This reduced control over the money supply can also impact financial stability through the central bank's ability to intervene in the foreign exchange rate market. In addition, speculation with respect to the virtual currency could occur due to the history of cyber attacks and since there is no lender of last resort for these currencies. In relation to payment system stability and lack of regulation, since the value of virtual currency depends on whether or not a second party is willing to accept the unit as a means of final payment, there is no guarantee of payment. Moreover, since there is no legal basis for virtual currencies, there is no clear definition of the rights and obligations of each party. ECB (2012) notes that the virtual currencies may be subject to price, financial, payment and lack of regulation risk, given that lack of interaction between virtual currencies and those issued by central banks. The paper, however, notes that these currencies do pose some degree of reputational risk for central banks, as most economic agents look to the central bank to ensure the smooth functioning of the payment and financial system. Therefore, if a major event does occur, the general public might perceive that the central bank was not doing its job effectively.

While ECB (2012) suggests that the implications for central bank policy at present might be limited, economic models and technological innovations within the banking system suggest that digital

money can impact the demand for money. Berentsen (1998), for example, notes that monetary policy depends on a stable velocity of money. However, as digital money becomes a popular means of payment, it can impact the income velocity of money and reduce the monetary base and more significantly diminish the precision of the central bank's control of monetary liabilities.

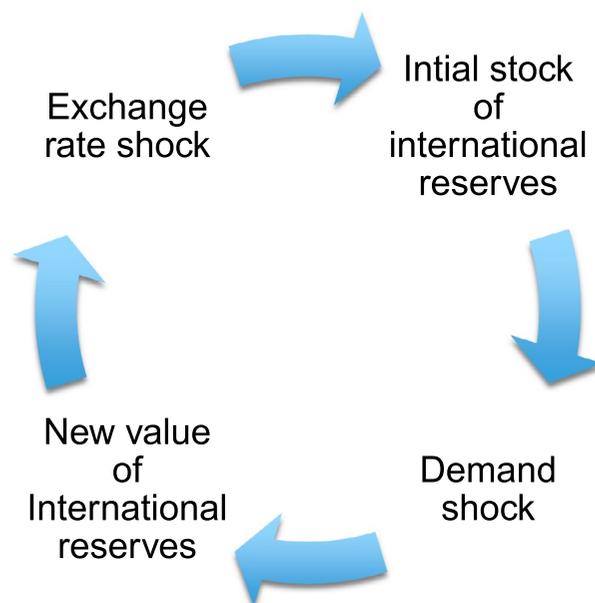
Given that digital currencies moderate the effectiveness of monetary policy at the country level, Plassaras (2013) argues for greater international cooperation through the International Monetary Fund (IMF). The author notes that central banks typically hold reserves to counter speculative attacks against the currency. They can also raise interest rates to further intervene in the currency market. If a central bank runs out of reserves, it can draw down on its quota's at the IMF. If wealthy Bitcoin investors launch a speculative attack on a currency, however, there is relatively little that can be done at present as neither the central bank nor the IMF hold Bitcoin. Plassaras (2013) therefore argues that the fund could either attempt to exercise indirect control of the currency or it could offer the digital currency a quasi-membership status. Such approaches will need to be further discussed as there are governance issues that need to be addressed; however, given the growth of Bitcoin, there is a clear need to be prepared for potential speculative attacks and to incorporate this means of payment better into the financial system.

3. Methodology

The present study employs two approaches to assess the viability of including Bitcoin in the international reserves portfolio of the Central Bank of Barbados. The first approach is a counterfactual simulation where it is assumed that a fixed proportion of the Central Bank's portfolio of foreign currency balances was invested in Bitcoin. The actual exchange rate changes are then applied to the portfolio to compare the simulated outcome relative to the actual outcome. This evaluation provides an assessment of the potential differences in volatility and returns that could have resulted from investments in Bitcoin. Relatively small investment ratios of 0.01, 0.1 and 1% are considered and for comparison purposes, a scenario where 5% of the reserves are invested in Bitcoin is also considered.

In the second approach, Monte Carlo methods are used to investigate the effects of randomly generated shocks on Barbados' portfolio of international assets over various forecasted time horizons (2015–2025). The likelihood that the stock of international reserve assets is exhausted in a given year of the simulation period is then calculated over 5,000 model iterations.

Figure 2. Representative model of Monte Carlo experiment.



International reserves at the end of each period are influenced by demand-side shocks, exchange rate shocks and the initial stock of international reserves (Figure 2). In each year of the simulation, the projected demand for imports and international payments is set equal to last period's reserves, plus randomly generated payments and exchange rate shocks. The mean and standard deviation of these shocks are linked to the historical value for the period 2009 to April 2015. The steps in the simulation are set to one month and a single run is performed for 1-, 2-, 5- and 10-year horizons. The analysis is then replicated 5,000 times and summary statistics are presented.

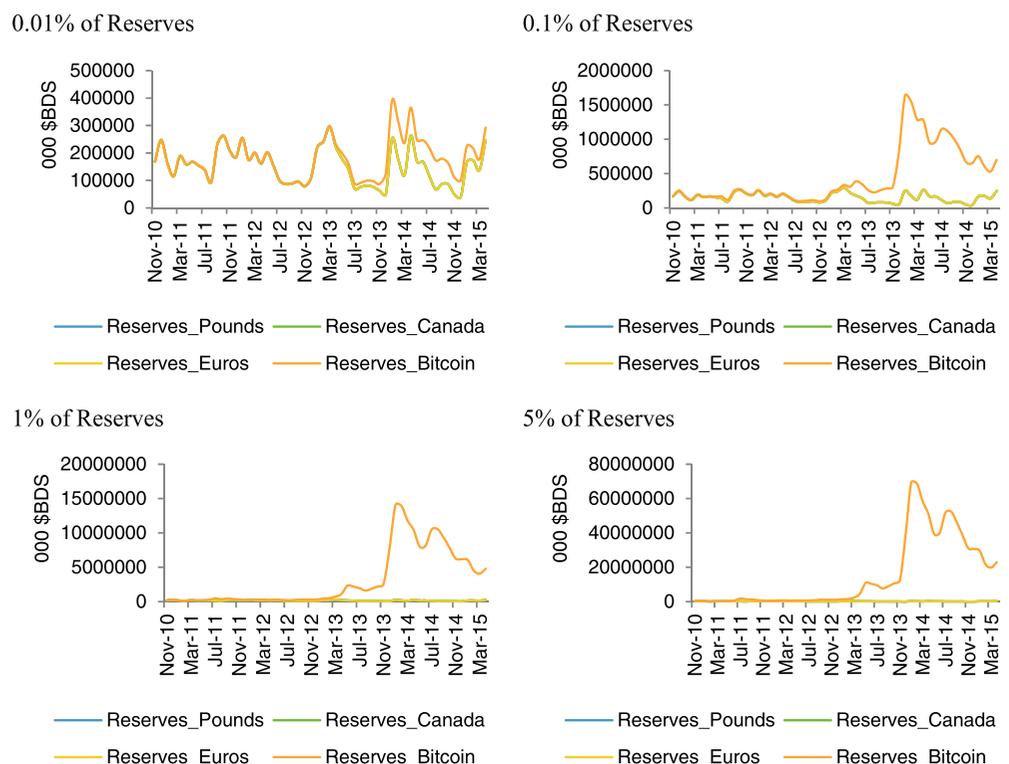
4. Cryptocurrencies as part of the international reserves

Counterfactual simulations conducted over the period 2009 to present suggest that adding Bitcoin to the reserve portfolio of the central bank would not significantly increase volatility but could provide opportunities to offset exchange rate changes against major currencies such as the Pound and the Euro. The figures assume that some fixed amounts of reserves are held in balances denominated in a particular currency at the beginning of the period and held for the remainder. These balances are therefore only affected by exchange rate changes.

In general, portfolios denominated in Pounds, Canadian Dollars and Euros all pretty much follow a similar pattern (and therefore only one line is visible in the charts). This result is not surprising, given that most major currencies revert to the purchasing power parity equilibrium against the US dollar (Li, 2015). The first scenario, where it is assumed that 0.01% of reserves were invested in Bitcoin or any of the other three major currencies held by the Central Bank of Barbados from November 2010 to April 2015 (Figure 3), suggests that the volatility of reserves would have been quite similar over the period. However, the Bitcoin reserves at the end of April 2015 would have been \$291,926, more than 20% greater than had these same funds been held in balances denominated in any of the other major currencies.

As the ratio of reserves invested in Bitcoin at the beginning of the period increases, the end of period balance diverges significantly from the actual outcome due to the appreciation of Bitcoin against the US dollar that occurred over the period. With just 0.1% of reserves in Bitcoin, balances at

Figure 3. Counterfactual simulations with various portfolio holdings of Bitcoin.



the end of April 2015 would have been more than twice the actual amount, 19 times greater with 1% of reserves and some 100 times greater with a relatively sizeable 5% of reserves in Bitcoin.

In addition to the counterfactual simulations, the paper also forecasts the likely future path of reserves over the next 10 years. This assessment is meant to illustrate the potential implications of incorporating Bitcoin into the portfolio of reserves up to 2025.

Similar to the counterfactual exercise, the simulations assume that a given proportion of reserves are held in balances denominated in Bitcoin. The assessment accounts for both payments and exchange rate shocks trained on historical patterns and therefore provides an appraisal of the likelihood that exchange rate and payments shocks could negatively impact foreign currency balances.

The results provided in Table 1 suggest that over the various forecast horizons considered, the risk of portfolio losses exceeding the initial investment is very low. Within a 1-year forecasts horizon, there were no simulated instances where portfolio losses were equal to the value of the initial investment. Over longer horizons, the number of instances of portfolio losses exceeding the initial investment obviously rises. However, when compared the instances of gains, the odds associated with such an even were quite small. Indeed, over a 10-year period, the odds were calculated as 47:629953.

The potential returns on these Bitcoin balances can also be quite significant. If historical values of the mean and standard deviation are used for the simulations, the portfolio value rises from just \$27,000 in May 2015 to \$224 million by the end of 2025. These projections obviously have a large margin of error, given the long forecast horizon being considered. In addition, using historical performance is not always a good gauge of future returns for financial assets.

Such a return on a small proportion of the foreign exchange balances (Figure 4) of the country is quite significant. Up to 2018, no significant impact on the reserves is observed. As the forecast horizon expands, however, potential returns on Bitcoin-denominated accounts could rise quite substantially, resulting in balances reaching as high as \$1 billion.

The impact that such an investment strategy has on the volatility of reserves can be quite significant, once Bitcoin's share of the foreign balances gets larger and larger. Up to 2018, the simulation suggests that the coefficient of variation of the portfolio would be quite small (Figure 5). After this period, once Bitcoin becomes a significant share of reserves due to anticipated appreciation, the volatility of reserves becomes quite significant.

To provide some context for the scenario results reported above, the same analysis is conducted using the historical values for British pound. Therefore, at the beginning of the simulation period,

Table 1. Holdings of Foreign currency and balances for portfolio of Bitcoin \$BDS (beginning of the period with a Bitcoin Portfolio of 0.01%)

Horizon	Minimum	Maximum	Mean	Standard deviation	Portfolio gain	Portfolio losses exceed initial investment
1	0.020	2,138.051	82.493	132.209	55,000.000	0.000
2	-0.125	43,672.828	351.432	1,353.700	114,993.000	7.000
5	-0.096	54709611.782	52,574.323	1014076.792	294,986.000	14.000
10	-2,374.090	334392942429.886	224352269.437	5997420787.878	629,953.000	47.000

Source: Authors' calculations.

Figure 4. Forecasted foreign exchange balances with 0.01% Bitcoin portfolio.

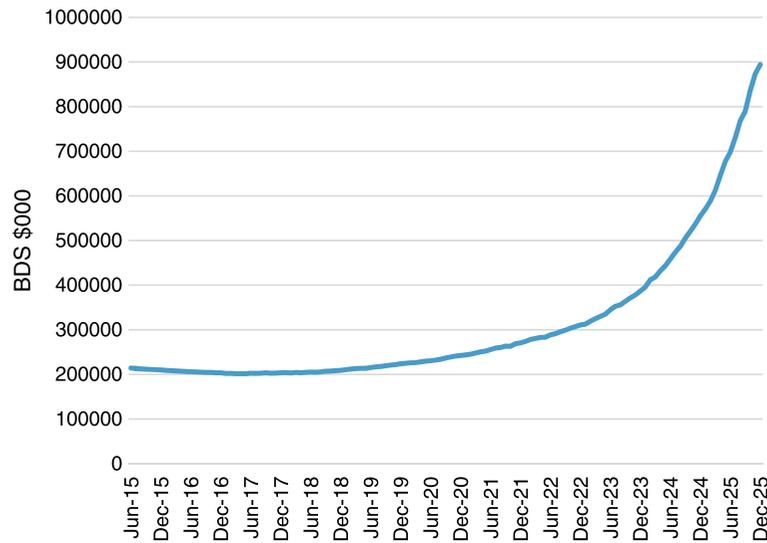
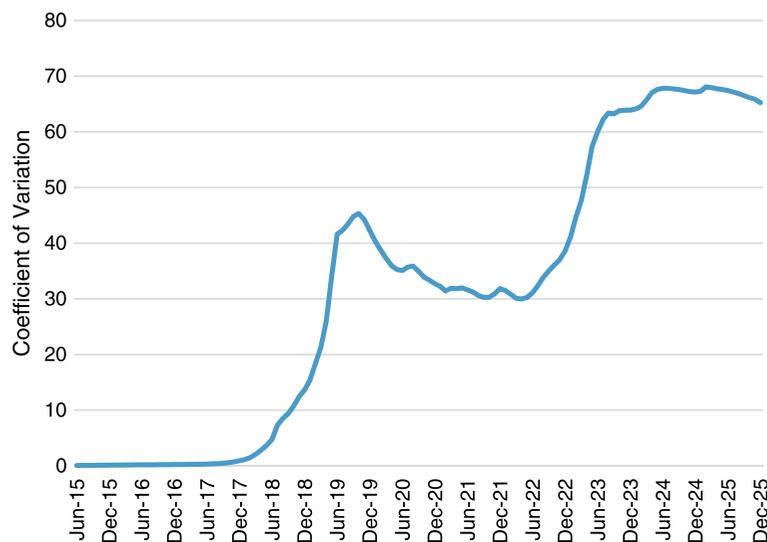


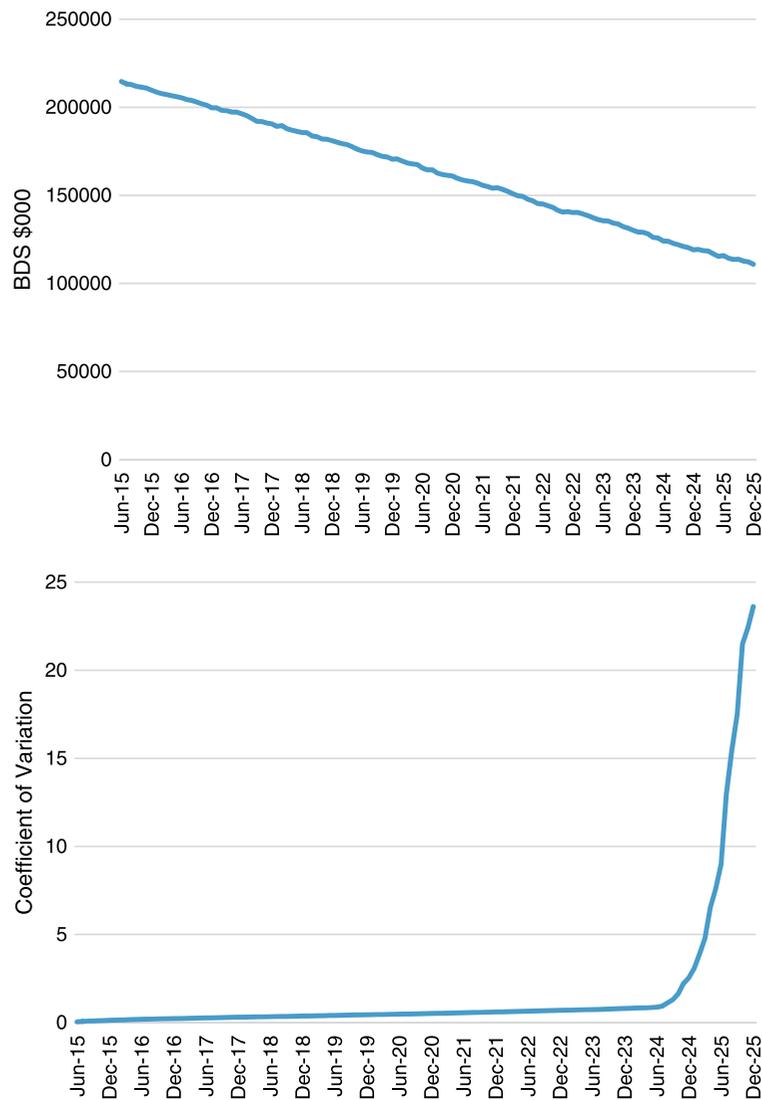
Figure 5. Forecasted coefficient of variation of foreign exchange balances with 0.01% Bitcoin portfolio.



0.01% of foreign currency balances are invested in Sterling-denominated currency and held for the remainder of the period. In contrast to the Bitcoin scenario, the simulation suggests that the Sterling portfolio would have a drag of just over \$100 million on foreign currency balances due to the expected depreciation in the exchange rate. In addition, while the coefficient of variation (Figure 6) of the portfolio of reserves is smaller over the 10- and 5-year horizons, it is not different from that for the Bitcoin portfolio over relatively short periods. In addition, similar to an investment in Bitcoin, there is still quite substantial uncertainty in relation to Sterling balances over relatively long horizons.

The findings reported above suggest that central banks may want to be careful of overinvesting in digital currencies at this time due to the tremendous volatility. However, relatively small portfolio amounts can result in significant returns, particularly as the adoption of these currencies become more prevalent and more trade is done using digital currency.

Figure 6. Forecasted reserves and coefficient of variation of foreign exchange balances with 0.01% sterling portfolio.



5. Discussion

The innovation that is the cryptocurrency is still very much in the early stages of adoption. As a result, there are many issues that have to be surpassed, particularly if a central bank will legitimately look at including Bitcoin, for example, in its reserve mix. A central bank must determine if it sees Bitcoin as a currency or a tradable asset. Most early adopting jurisdictions consider cryptocurrencies as assets and, as such, there are capital tax implications for their sale and purchase. One could reckon that given the insignificant amount, the paper recommends that the Central Bank of Barbados should hold to reduce its risk exposure, that matching orders for the block purchase of the “asset” in exchange for any other reserve currency may be cumbersome to the bidding party in the said jurisdictions. Though current market participant preferences say otherwise (Glaser et al., 2014), a jurisdiction and, by extension its central bank, that legally recognises cryptocurrencies as a currency could do more than reduce the already declining cost of transactions when disposal is necessary, but it could also attract more foreign direct investment in the country for active and, hopefully, legitimate participants. Notably, the cost of transmissions over the Blockchain fell approximately by 80% over the past year (2015).

The markets for the sale of Bitcoin and other cryptocurrencies are also still held under much scrutiny due to the anonymity of counterparties. It is for that reason that unless commercial banking,

financial and central banking entities actively participate in the market, regulators will continue to express caution or in the case of China, a swift and explicit ban on the holding of cryptocurrencies by commercial banks within the jurisdiction. This is so despite China having the largest proportion of cryptocurrency users worldwide. However, Citibank's intention to create its own cryptocurrency for primarily transactional services does present a model for financial entities, if not central banks, to follow (Madore, 2015).

An alternative strategy would be for the Central Bank of Barbados to consider mining Bitcoin, but here the costs outweigh the immediate benefits. The cryptographic algorithm that governs the production of new Bitcoin for sale becomes more difficult to solve every time a new Bitcoin is produced. And since the algorithm is using a peer-to-peer technology protocol to manage this process, every accessible mining system is aware of the creation of new Bitcoin by miners. Anecdotally, for the Central Bank of Barbados to competitively enter this space, it would not only need to procure an already expensive expertise and commit considerable investment into rapidly evolving mining technologies, but it would have to endure the already escalating diminishing returns to scale on investment being seen by new mining entrants into the market. It would therefore be more prudent if the Central Bank of Barbados be an active trader of the asset/currency while focusing on utilising tools to transmit cryptocurrencies over the Blockchain. The primary purpose for this would be to replace or to supplement the current SWIFT and RTGS systems and would work by the transmitted cryptocurrency becoming nothing more than a trading mechanism to balance accounts between the seller and buyer of a particular fiat currency. For example, if the Central Bank of Barbados wishes to sell Barbadian dollars in exchange for US dollars, it could purchase, in real time, the market value equivalent in Bitcoin from a seller who has a demand for Barbadian dollars and then simultaneously that Bitcoin is sent to a buyer who wishes to purchase it for the market value in US dollars. Given the effectiveness and unmatched speed of the Blockchain protocol, inflation risk and market risk are effectively minimised once there is a matching counter-party. A central bank basically becomes a clearing house for the cryptocurrency. The authors believe that once more participants of the likes of Citibank continue to enter the market and support transactions via the Blockchain, that the counter-party risks to smaller and highly vulnerable central banks, such as the Central Bank of Barbados, will be minimised.

6. Conclusions

This paper provides an assessment of the potential benefits and costs of holding Bitcoins as part of the portfolio of international reserves using the case of Barbados. Within recent years, the proportion of digital transactions done using digital currencies has grown significantly. As a result, it is possible that digital currency could become a key currency for settling transactions. In addition, given that Barbados maintains a peg against the US dollar, it is necessary that the Central Bank of Barbados holds enough of various currencies as a precaution against speculative attacks.

The paper uses two main empirical tools to conduct the analysis: a counterfactual exercise using historical performance of the various exchange rates (including Bitcoin) as well as a Monte Carlo forecast of international reserves for the next 1, 2, 5 and 10 years using a relatively small portfolio composition of Bitcoin (0.01%). The counterfactual exercise suggests that had the Central Bank of Barbados held a relatively small proportion of its portfolio in Bitcoin between 2009 and 2015, the impact on reserve balance volatility (due to exchange rate variation) would not have been significantly different from that experienced with other major currencies. In addition, the appreciation in the value of the Bitcoin portfolio (in US dollars) would have also generated a significant return for the bank. The Monte Carlo forecasting exercise yields similar results. However, the paper notes that as the proportion of reserves held in Bitcoin rises, the volatility of reserves would also increase. Given that the proportion of transactions done by Barbadians in digital currency is not likely to exceed 10% of all transactions in the short run, it is therefore recommended that if Bitcoin is incorporated into the portfolio of foreign balances of the Central Bank of Barbados, its share should be relatively small.

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