NBC Working Paper[1]

Foreign Assets Management Under the Climate Change ERA
Case Study of the National Bank of Cambodia

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Contents

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[1] NBC Working Papers describe research in progress by the authors and are published to elicit comments. The views expressed in NBC Working Papers are those of the authors and do not necessarily represent the views of the NBC.

I. Introduction

Climate change has become a critical global concern, with extensive implications for economies, societies, and the environment. Central banks worldwide are increasingly recognizing the need to address climate-related risks and promote sustainable development. The National Bank of Cambodia (NBC), as the central bank of the Kingdom of Cambodia, is actively observing and considering incorporating environmental, social, and governance (ESG) and socially responsible investment (SRI) principles into its foreign assets management practices. This research aims to delve into NBC's approach to managing foreign assets in the era of climate change, examining its current practices and other central banks' practices, identifying challenges and opportunities, and providing recommendations to enhance its approach. By exploring NBC's efforts, this research seeks to contribute to the broader discourse on central banks' role in addressing climate change and fostering sustainable development.

I.1. Background of Research

In recent years, there has been a noticeable global trend among central banks towards incorporating climate considerations into their investment strategies. This shift reflects a growing recognition of the financial risks associated with climate change and the importance of aligning investment portfolios with sustainability objectives. Central banks have actively participated in debates and discussions on integrating environmental, social, and governance (ESG) and socially responsible investment (SRI) criteria into their investment mandates. Notably, there has been a specific emphasis on investments in green bonds and SRI bonds, which support environmentally friendly and socially responsible projects. Following the trend of the global central banking community, NBC is now considering joining this movement, exploring avenues for sustainable investments, and seeking to enhance its foreign assets management practices to effectively respond to the challenges posed by climate change.

I.2. Research Aim

This study aims to investigate the rationale behind NBC's consideration of investing in Green and Sustainable Bonds and incorporating ESG criteria into its investment mandate. Additionally, the research aims to explore effective strategies for managing NBC's foreign assets in the context of climate change. Furthermore, the study seeks to examine the benefits, costs, and challenges associated with the implementation of ESG and SRI criteria, as well as the adoption of Green and ESG bond investments by other central banks. Lastly, the research aims to assess the potential costs and implications for NBC in aligning its investment mandate with ESG criteria and integrating Green and ESG bond investments, particularly considering the challenges posed to traditional investment mandates focused on capital preservation, liquidity, and return.

I.3. Research Objectives

This study aims to analyze the motivations and considerations driving NBC in its interest in investing in Green and Sustainable Bonds and incorporate ESG criteria into its investment mandate. The objective is to gain a deeper understanding of the perceived benefits and underlying drivers of these actions. Additionally, the research aims to assess the potential costs, challenges, and implications that NBC may face as it aligns its investment mandate with ESG criteria and integrates Green and ESG bond investments. The specific focus will be on

examining the impact on traditional investment objectives, such as capital preservation, liquidity management, and competitive investment returns.

I.4. Research Questions

To address the objectives above, the research questions will focus on the impact of climate change on foreign assets management in the context of NBC's following:

1. What are the motivations and considerations driving NBC in its interest in investing in Green and Sustainable Bonds and incorporating ESG criteria into its investment mandate?
2. What are the potential costs, challenges, and implications that NBC may face as it aligns its investment mandate with ESG criteria and integrates Green and ESG bond investments, particularly about traditional investment objectives such as capital preservation, liquidity management, and competitive investment returns?

I.5. Research Contributions

This study aims to contribute to the understanding of central banks' role in addressing climate change and promoting sustainable development by focusing on NBC. By investigating the motivations and considerations behind central banks' interest in sustainable investments including NBC and assessing the potential costs and challenges associated with aligning its investment mandate with ESG criteria, this research provides insights into the broader discourse on sustainable finance. Additionally, by examining the impact on traditional investment objectives, such as capital preservation and liquidity management, the study aims to provide recommendations for enhancing NBC's approach to managing foreign assets in the era of climate change. The findings of this research can assist NBC’s foreign assets managers in developing strategies and practices that effectively address climate-related risks as well as persuade NBC’s management to acknowledge and consider including ESG and SRI into foreign assets management practices.

II. Literature Reviews

Climate change is a global concern with far-reaching implications across various sectors. Among these, the effect of climate change on central banks and their management of foreign assets has gained significant attention. As countries grapple with the consequences of a changing climate, central banks worldwide face the challenge of adapting their policies to address both the risks and opportunities that arise. This section aims to provide a comprehensive literature review on the impact of climate change on the central bank’s foreign assets management. Additionally, it will present conceptual and theoretical frameworks to answer the research questions at hand.

This research will draw upon several theories and concepts in line with the conceptual and theoretical framework. In this context, regarding the impact of climate change on foreign assets management following key concepts and theories can be considered such as (i) Foreign Assets Management (ii) Financial economics theory for climate change (iii) Portfolio Theory, and (iv) Sustainable Finance and ESG. By combining the theoretical framework and conceptual framework, this research aims to provide a robust analytical framework for studying the behavior

of central banks in managing foreign assets in the era of climate change. The utilization of these frameworks will guide the analysis, interpretation, and synthesis of existing literature and case studies, enabling a comprehensive assessment of the challenges, opportunities, and potential measures for central banks in consideration of including ESG and SRIs in their investment of foreign assets.

II.1. Conceptual Framework: Foreign Reserves Management

In this context, foreign assets held by central banks can be known as foreign reserves that invest abroad. Hargrave (2019) defines foreign assets held by a central bank as assets denominated in foreign currencies that are held by a nation's central bank. These assets are typically used to back liabilities and influence monetary policy. Foreign assets can include foreign currencies, bonds, treasury bills, gold, and other government securities. In addition, managing these foreign assets is an important task for central banks. According to the handbook of foreign reserve management published by the Center for Bank Studies (CBS) of the Bank of England, Nugée, J. (2020) stated that reserve management is a complex and time-consuming business. It requires clear objectives, extensive delegation, robust control systems, open and transparent reporting, and a realistic appreciation of the constraints. If conducted properly, openly, and successfully it will significantly strengthen the public's respect for and confidence in official policy and can make a material contribution to successful macro-economic management.

The IMF Guideline on FX Reserves Management has stated that the objective of foreign reserves management is to ensure several objectives including (i) adequate foreign exchange reserves are available for meeting a defined range of objectives; (ii) liquidity, market, and credit risks are controlled prudently; and (iii) subject to liquidity and other risk constraints, reasonable earnings are generated over the medium to long term on the funds invested.

Following the IMF Guideline on the importance of holding foreign reserves and the objectives of foreign reserves management, Hentov et. al (2017), stated that these objectives have been traditionally quite narrow and can be summarized as follows: (i) exchange rate management and backing the domestic currency, if applicable, (ii) maintaining external liquidity and supporting market confidence therein, (iii) supporting the government in external debt management and (iv) maintaining an emergency reserve. This informs the traditional approach to reserve management, governed by objectives of, order of priority, safety, liquidity, and return. In addition, while safety and liquidity remain the primary priorities, the focus on return has increased in recent years, contributing to the diversification of the central bank reserve portfolio. The increased focus on return is a result of excess reserves (sufficient/above the liquidity needs or meeting the worst-case scenario requirement for reserves in a balance of payment crisis). With these specific characteristics, central banks are not passive investors with lower risk tolerance, they can be active investors with medium risk tolerance. In addition, the central banks as investors have responded to the policy signals of other central banks and have sought out higher-yield assets in the era of quantitative easing (lower yield environment).

However, the IMF's Guideline for Effective Reserve Management was revised in 2013. The revision aimed to help strengthen the international financial architecture, promote policies and practices that contribute to stability and transparency in the financial sector, and reduce member countries' external vulnerabilities. The Guideline has defined reserves management as a process that ensures that adequate official public sector foreign assets are readily available to and controlled by the authorities for meeting a defined range of objectives for a country.

According to the guidelines, foreign exchange reserves need to support a range of objectives, including:

- Support and maintain confidence in the policies for monetary and exchange rate management, including the capacity to intervene in support of the national or union currency,
- Limit external vulnerability by maintaining foreign currency liquidity to absorb shocks during times of crisis or when there is a limit on access to borrowing, and in doing so,
- provides a level of confidence to markets that a country can meet its external obligations,
- Demonstrate the backing of domestic currency by external assets,
- Assist the government in meeting its foreign exchange needs and external debt obligations, and
- Maintain reserves for national disasters or emergencies.

The guidelines are also basically focused on core areas of reserves management, which include reserves management objectives, scope and coordination, transparency and accountability, institutional framework, risk management framework, and role of an efficient market. In addition, the Guideline also mentions that the reserve management should seek to ensure adequate the foreign reserve is ready to meet pre-defined objectives, control liquidity, market, and credit risk, and generate returns over the medium and long term on funds invested.

According to IMF's guideline (2013), sound reserve management practices are essential because they can increase countries' or regions' overall resilience to shocks. The importance of sound practices has also been highlighted by experiences where weak or risky reserve management practices have restricted the ability of the authorities to respond effectively to financial crises, which may have emphasized the severity of these crises.

The movement of global politics, economy, financial market situation, and other ad hoc events are significant causes that encourage foreign reserve managers to be flexible in managing asset management and allocation strategies. For example, the world has faced climate change issues, including changes in weather, floods, drought, and other natural disasters. These issues have strongly affected human health and living. In addition, the CFA Institute published a report on Climate Changes in the Investment Process (2020), mentioning climate change's economic and market implications. Climate change has an economic impact that has an estimated cost of around US$4.2 trillion, and it can increase in the future. Therefore, foreign reserve managers have changed their interest in climate change due to the higher economic cost.

In addition, the relationship between the IMF's guidelines on Foreign Reserves Management, which specifically focuses on sound foreign reserve management (stability and adequacy of foreign reserves), and climate change affects economies and financial systems, especially the management of foreign exchange reserves. Climate change effects can introduce new risks that need to be considered in the assessment of foreign reserve management. For example, countries may need to evaluate the exposure of their reserves to climate-related risks, such as investments in industries vulnerable to climate change impacts. Furthermore, climate change effects can influence the diversification strategies of foreign reserves. For instance, countries may consider diversifying their reserve portfolios to include investments in sectors or assets that are resilient to climate change or contribute to climate mitigation and adaptation efforts. Climate change can also influence policies and international agreements, such as the Paris Agreement. For example, countries may need to coordinate their reserve management policies with climate-related commitments and regulations to ensure alignment and minimize potential risks. In addition, climate change is a long-term challenge that countries may need to incorporate climate-related considerations into their long-term reserve management strategies.

Indeed, it is crucial to establish sound foreign reserves management that not only considers traditional financial goals but also incorporates climate-related aims. This results in creating resilient foreign reserves investment and management strategies that consider the potential impacts of climate change. By integrating climate change considerations into reserve management practices, countries can contribute to climate mitigation and adaptation efforts while safeguarding their financial stability.

II.2. Theoretical frameworks: Financial economics theory for climate change

This section discusses financial economics theory in the context of climate change. Financial economic theory provides a framework for understanding the economic implications of climate change and the role of financial markets in addressing climate-related risks. The study of financial economics theory for climate change can explore the relationship between financial markets, economic variables, and investment decisions. For example, this study will examine the impact of climate change on financial markets, asset prices, and the financial performance of companies (issuers of bonds).

According to Giglio, Kelly, and Stroebel (2021), they discuss climate risk and asset prices as they developed economic models to incorporate climate change risk and analyze its impact on asset prices. These models aim to understand how climate-related factors, such as extreme weather events or regulatory changes, can affect the valuation of financial assets including real estate, equities, and fixed-income securities. Nur Utomo et al. (2020) conducted studies that examined the relationship between a firm's environmental performance, its disclosure of environmental information, and its market value. These studies aim to understand how environmental factors can impact a firm's financial performance and market valuation. For example, the study of the relationship between environmental performance, environmental disclosure, and firm value of non-financial companies listed on the Indonesia Stock Exchange. In addition, Whelan et al. (2021) also discuss financial performance and climate change as they

explore the relationship between a company's financial performance and its response to climate change. This study also found positive correlations between environmental, social, and governance (ESG) practices and financial performance as well. The research also highlights the potential benefits of sustainability initiatives at the corporate level, such as improved risk management and increased innovation, in driving better financial performance.

According to UNFCCC (2022), they discuss and define climate finance which refers to the financing drawn from public, private, and alternative sources to support mitigation and adaptation actions addressing climate change. In this context, financial economics theory explores the mechanisms and sources of climate finance, including public investment, private sector involvement, and international cooperation. It recognizes the need for financial assistance from countries with more resources to those that are less endowed and more vulnerable to climate change.

Therefore, the financial economics theory for climate change is the economic principles and theories that are applied to analyze the economic impacts of climate change, to assess the costs and benefits of climate mitigation and adaptation measures, and to examine the role of financial markets, institutions, and policies in addressing climate-related challenges.

II.3. Theoretical Frameworks: Portfolio Theory

This section discusses portfolio theory, within the context of climate change, and will explore the integration of climate-related risks and opportunities into investment portfolios. This also means applying modern portfolio theory to incorporate climate-related risks and opportunities into investment portfolios. Several studies have been conducted and provided insights into this area. Eaton et al. (2019) conducted studies to explore the application of modern portfolio theory to address climate change risks in spatial conservation planning. The study also addresses the challenge of uncertainty in conservation planning by adapting the principles of modern portfolio theory, commonly used in financial investment, to optimize conservation strategies. In addition, this study also proposes a framework that treats conservation actions as a portfolio of assets, aiming to maximize the expected conservation outcomes while considering the uncertainties associated with climate change impacts. Cosemans, Hut, and Van Dijk (2021) also agree that addressing risks related to climate change should be optimized. They conducted studies to explore the impact of climate change on long-term portfolio choice and combine theoretical insights with empirical analysis. This is an approach for measuring the impact of climate change on long-horizon equity risk and optimal asset allocation by examining how climate change risks can affect the performance and composition of investment portfolios over extended time horizons. Additionally, a recent study conducted by Chakrabarty and Nag (2023) addressed the challenges and opportunities that climate change brings to the finance sector, particularly in terms of mitigating climate-related risks and investing sustainably. Their study highlights the importance of suitable risk measures and portfolio management approaches to move away from firms with high carbon footprints and support sustainable investment decisions.

Therefore, these studies collectively contribute to the understanding of how modern portfolio theory can be adapted and applied to address climate change risks in spatial conservation planning, long-term portfolio choice, and sustainable investment decisions. They provide

insights into optimizing conservation strategies, managing climate-related risks, and promoting sustainable investment practices.

II.4. Theoretical Framework: Sustainable Finance and ESG

This section discusses sustainable finance and ESG integration, in the context of climate change, which have gained significant attention in recent years. The integration of ESG issues into financial decisions is a key aspect of sustainable finance. Several studies have been conducted and provided insights into this area.

Edmans and Kacperczyk (2022) focus on sustainable finance and the integration of environmental, social, and governance (ESG) issues into financial decisions. This study aims to explore the growing importance of ESG considerations in investment decision-making by examining the impact of ESG factors on portfolio-level ESG scores and finding that non-US signatories have superior ESG portfolio-level scores. In addition, Lee and Suh (2022) also explore the relationship between the integration of ESG and financial performance as they also agree on the importance of considering ESG factors in financial decision-making and providing insights into how these factors can impact the financial performance of companies.

ESG consideration in financial decisions can provide benefits to companies and firms since ESG can create value. Henisz, Koller, and Nuttall (2019) explore how ESG factors can contribute to value creation in businesses. They analyzed the interconnectedness of ESG elements and their impact on long-term success. Furthermore, this study may provide insights into how companies can integrate ESG considerations into their business strategies to drive financial performance and create value.

Indeed, these studies highlight the growing importance of ESG considerations in investment decision-making, the potential impact of ESG factors on financial performance, and the value-creation potential of ESG integration in businesses.

II.5. Research Gap

The existing conceptual and theoretical frameworks on climate change in the context of foreign assets management provide valuable insights into various aspects, such as foreign reserves management, portfolio diversification, climate change's impact on the economy and financial markets, and sustainable and green bond investment. However, there is a lack of comprehensive studies that specifically examine how central banks incorporate climate change adaptation and mitigation strategies into their foreign asset management practices. This research gap highlights the need to explore how central banks can effectively integrate climate change adaptation and mitigation strategies within their foreign reserves management practices. Factors to consider in this integration include portfolio diversification, green investments, and engagement with sustainable finance and Environmental, Social, and Governance (ESG) principles.

III. Research Design

III.1. Research Philosophy

The research philosophy for this study adopts a combined positivist and interpretivist approach. Positivism, as a philosophical stance, highlights the objective and empirical examination of

phenomena. In this study, positivism will be employed to collect quantitative data concerning the motivators and reasons behind NBC's contemplation of investments in ESG and green bonds. Through quantitative methods such as surveys and financial data analysis, positivism enables the collection and analysis of measurable data, thereby facilitating insights into NBC's motivations and reasons for considering these investments. By employing statistical evidence, the study aims to comprehend the quantifiable factors that drive NBC's decision-making process.

In contrast, interpretivism serves as a philosophical approach that focuses on understanding and interpreting subjective experiences and meanings. In this study, interpretivism will be applied to gain an understanding of the subjective experiences and perspectives of other central banks in adopting ESG and SRI practices within their foreign assets management mandates. Recognizing that individuals and organizations possess distinct viewpoints, interpretivism acknowledges the influence of subjective factors such as beliefs, values, and cultural contexts on decision-making processes. Qualitative methods such as existing literature reviews and case studies will be employed to explore the motivations, challenges, and lessons learned by other central banks. By delving into their subjective viewpoints, the study aims to attain a deeper understanding of the potential benefits and considerations associated with the adoption of ESG and SRI practices in foreign asset management.

The integration of positivism and interpretivism in this research offers a comprehensive understanding of the motivators and reasons underlying NBC's considerations of ESG and green bonds, while also providing insights into the subjective experiences and perspectives of other central banks. This combined approach facilitates a holistic examination of the research topic, enhancing the validity and richness of the findings.

III.2. Research Framework

This research will adopt a multi-faceted framework to investigate the incorporation of ESG and green bonds by NBC in their foreign assets management practices. The framework consists of three interconnected components, namely Motivation and Reasons, Cost Analysis, and Decision-Making Input.

The Motivation and Reasons component involves an extensive review of existing literature on ESG and green bond investments as well as review surveys conducted by international institutions such as the World Bank, BIS, and NGFS. By examining the experiences of other central banks that have already embraced ESG and green bonds, this component aims to identify the motivators and reasons behind NBC’s consideration of such investments. The analysis will delve into the potential benefits, challenges, and opportunities associated with ESG and green bonds, providing valuable insights into the factors driving NBC's decision-making process.

The Cost Analysis component aims to assess the financial implications of transitioning from the current portfolio to one that integrates ESG and green bond considerations. This analysis will involve the evaluation of financial data, including potential investment opportunities, associated risks, and expected returns. By conducting a thorough cost analysis, this component aims to provide a comprehensive understanding of the financial feasibility and potential benefits of incorporating ESG and green bonds within NBC's foreign assets management mandates.

The Decision-Making Input component will synthesize the findings from the Motivation and Reasons component and the Cost Analysis component. Based on this synthesis, the research will offer insights and recommendations to NBC's management, providing them with valuable input for making informed decisions regarding the integration of ESG and green bonds, as well as the adoption of ESG and SRI principles within their foreign assets management mandates. These recommendations will consider factors such as portfolio diversification, capital preservation, liquidity, and return objectives, to support NBC in aligning their practices with sustainable finance and ESG principles.

By employing this research framework, this study seeks to contribute to the existing knowledge gap by providing an in-depth analysis of how central banks, with a specific focus on NBC, can effectively integrate climate change adaptation and mitigation strategies into their foreign asset management practices. It aims to address the research gap surrounding the comprehensive study of central banks' incorporation of ESG and green bond considerations while providing practical insights and recommendations for NBC's decision-making process.

III.3. Data Collection

The research will use a mixed-methods approach, incorporating both qualitative and quantitative data collection methods. Each approach will be utilized to accommodate the research objectives effectively.

For the qualitative approach, existing surveys, interviews, and case studies conducted by reputable international institutions such as the BIS, NGFS, World Bank, IMF, Climate Initiative, climate change databases including the Intergovernmental Panel on Climate Change (IPCC), and relevant academic research articles will be analyzed. These sources will provide valuable information on the experiences of central bank officials with foreign assets management encountering climate change. These reports and studies are publicly available on the websites of these institutions and are considered secondary data.

In addition, the quantitative approach will require data on economic and financial indicators related to foreign assets management and climate change. This data, also considered secondary, is publicly available and will be used to answer specific research questions.

By employing a mixed-methods approach and utilizing both qualitative and quantitative data collection methods, this research aims to gather comprehensive insights into the impact of climate change on foreign reserve management. The qualitative analysis of existing surveys, interviews, case studies, and academic research articles will provide a rich understanding of the experiences and perspectives of central bank officials. At the same time, the quantitative analysis of economic and financial indicators will enable a more rigorous examination of the relationship between climate change and foreign reserve management.

III.4. Data Analysis

This study adopts a mixed-methods approach to investigate the reasons behind NBC’s consideration of ESG factors and green bonds. The research relies on publicly available data that

has already been published. The analysis involves a combination of qualitative and quantitative methods to gain insights into the research topic.

Qualitative analysis involves a comprehensive examination of existing literature and other publicly accessible written materials. The research applies techniques such as thematic coding and content analysis to identify significant themes and patterns related to the motivations behind NBC's consideration of ESG and green bonds. Additionally, the experiences of other central banks in adopting ESG and socially responsible investment (SRI) principles are explored. Thematic coding and content analysis aid in elucidating the underlying reasons and providing a nuanced understanding of the research phenomenon.

On the other hand, quantitative analysis requires the examination of financial data and conducting cost analysis. The study utilizes publicly available financial reports, annual reports (by central banks and international institutions), and other relevant data sources to assess the potential financial impact of integrating ESG and green bonds into NBC's foreign assets management. Statistical techniques are employed to evaluate investment opportunities, assess associated risks, and estimate expected returns. This quantitative analysis provides a systematic and rigorous assessment of the financial implications of incorporating ESG and green bonds.

III.5. Limitations

It is important to acknowledge that there may be limitations in accessing precise and individual-level data and information, as such data is often not publicly available. Consequently, this research will rely on aggregate data and information, which provides a broader perspective but may lack the granularity of individual-level data.

IV. Motivation for Central Bank Adapting Strategies to Climate Change

This section will investigate the motivations and reasons underlying the inclusion of ESG factors and SRIs in the foreign assets management mandates of central banks, with a specific focus on NBC. Additionally, this section also explores the motivation of central banks to invest in green bonds and sustainable bonds as part of their investment strategies. By delving into these motivations, this research seeks to contribute to the understanding of the evolving role of central banks in sustainable finance practices.

IV.1. Recent Trend of Central Bank Considering ESG and SRIs

In recent years, there has been a growing recognition among central banks worldwide regarding the significance of climate change and the associated risks, both direct and indirect, to their operations. This recognition extends particularly to the management of foreign assets, where central banks play a crucial role. Based on these growing concerns, many central banks considered and discussed the inclusion of ESG and SRIs in addition to their traditional foreign reserves management mandates (safety, liquidity, and returns).

According to Fender et al. (2020), the survey conducted among central bank reserve managers revealed that a significant majority, specifically two-thirds (68%) of respondents, agreed that sustainability could be considered as a fourth objective in reserve management. This finding highlights the increasing recognition among central banks of the relevance and importance of

incorporating sustainability considerations into their asset management practices. Furthermore, another survey conducted by the BIS in 2021 provided additional insights into the perceptions of central bank reserve managers regarding the relevance of sustainability in asset allocation (Fender et al., 2020). The survey found that over 50% of respondents reported that sustainability is either "somewhat" or "highly" relevant to their asset allocation decisions. This indicates that a significant portion of central banks recognize the potential impact of sustainable investment practices on their portfolio allocation strategies.

Fender et al. (2022) explore two distinct approaches through which central banks can integrate sustainability objectives in their foreign exchange (FX) reserve management. The first approach, explicit integration, entails the explicit declaration of FX reserves to bolster the country's achievement of the United Nations' Sustainable Development Goals (SDGs) or to facilitate the transition to a net-zero economy. This approach, however, presents complexities as it necessitates substantial changes to key governance documents, enabling central banks to legally pursue sustainability objectives. The second approach, implicit integration, involves recognizing the indirect implications of sustainability, or its absence, on existing policy objectives within reserve management. For example, central banks employing FX reserves to enhance investor confidence may need to adjust their portfolios by favoring assets deemed less vulnerable to long-term losses arising from environmental risks or the transition to a low-carbon economy. Implicit integration encompasses an understanding of how ESG challenges can influence the conventional (traditional) purposes of holding FX reserves, spanning both risk management and the potential impact on policy objectives.

In addition, Fender et al. (2022) also identify 12 channels for integrating sustainability into reserve management such as below:

1. Investing in instruments issued for sustainable purposes: purchasing green, social, sustainable, and/or sustainability-linked bonds.
2. Investing in funds with sustainable objectives: purchasing funds or benchmarks with explicit sustainable targets
3. Implementing negative screening: Excluding companies that do not fit specific principles (for example, ethical) from the investment universe.
4. Using ESG metrics for investment decision-making: Introducing ESG ratings as a criterion for performing security selection.
5. Introducing notions of climate risk in the central bank’s investment beliefs: adjusting internal documentation to reflect the latest empirical evidence on risk premia (for example, carbon risk).
6. Quantifying the environmental impact of the portfolio: estimating the carbon footprint and/or intensity of overall reserve assets.
7. Adjusting portfolio composition based on climate data: sustainable growth investing (for example, in low carbon or climate-resilient private equity investments.
8. Adopting asset and risk management tools that integrate environmental risks: conducting climate scenario analysis or stress tests for the central bank’s assets.
9. Setting climate or other sustainability-related targets: adjusting the portfolio composition over time such that the implied temperature path is consistent with the Paris Agreement.

10. Operating in a sustainability-aware network: dealing with counterparties that commit to Sustainable Development Goals.
11. Active Ownership: seeking to actively influence corporate behavior to ensure the invested companies are managed sustainably.
12. Enhancing Transparency: Disclosing sustainable investment practices to the public.

Integration of sustainability into reserve management does not necessarily require the use of all 12 channels. Central banks typically employ at least 2 or 3 channels to incorporate sustainability. These include Channel 1, which involves investing in instruments issued for sustainable purposes, Channel 3, which focuses on implementing negative screening, and Channel 4, which involves using ESG metrics for investment decision-making.

In addition to considering ESG factors, central banks have also shown interest in adopting SRI principles in their portfolio management frameworks and processes. Organizations like NGFS, BIS, and the World Bank have conducted surveys to gauge central banks' inclusion of ESG considerations in their investment frameworks and practices. However, it is up to each central bank to decide whether to incorporate these matters into their investment practices.

The NGFS survey conducted in 2019 revealed that out of the 27 central banks surveyed, 25 already manage portfolios that include or are considering including SRI principles. The BIS survey conducted in 2020 found that 35 correspondents from central banks were satisfied with including sustainability considerations in pursuing their policy objectives, and 69 correspondents agreed on the importance of including sustainability as a reserve management objective. These survey results indicate that many central banks have expressed interest in SRI and have already implemented or are considering implementing these policies. Furthermore, Kyriakopoulou and Hyrske (2022) acknowledged that central banks are increasingly recognizing the need to align their operations with sustainability objectives while some central banks have already begun to explore and act on the sustainability implications for their identity as managers of investment. However, compared to other public investors like pension funds and sovereign wealth funds, central banks have made slower progress in adopting sustainable investment practices. It is important to note that the surveys conducted by various international institutions provide a collective view of participating central banks. These surveys offer valuable insights into the perspectives and actions of central banks regarding sustainability, but they do not represent the views of every central bank.

The Bank of Japan (BOJ) has announced its intention to purchase green bonds using its foreign reserves as part of its efforts to promote global investment in activities aimed at combating climate change. However, it's important to note that Japan's $1.4 trillion in foreign reserves is predominantly held by the Ministry of Finance, not the BOJ. Therefore, the BOJ's decision to buy green bonds is likely a symbolic move to raise awareness about the importance of promoting green finance. The BOJ currently holds approximately $70 billion of those foreign assets (Kihara and Kajimoto, 2021).

According to a press release from the European Central Bank (ECB), the ECB has announced its intention to invest in the BIS green bond fund. This move is part of the ECB's efforts to increase

sustainable and responsible investments. The BIS has launched a second green bond fund for central banks, which invests in high-quality bonds that comply with international green standards and finance environmentally friendly projects. The ECB's investment in this fund is aligned with its sustainable investment strategy for its own funds portfolio, which totals 20.8 billion euros. The ECB is also exploring the expansion of low-carbon benchmark indices to fixed-income asset classes within its staff pension fund. These initiatives demonstrate the ECB's commitment to promoting environmental responsibility in the financial sector and supporting environmentally responsible investment practices.

Central Bank of Ireland also follows the ECB to announce its participation in the euro-denominated green bond investment fund for central banks established by BIS. The investment follows the participation of the Central Bank in the BIS US dollar-denominated green bond investment fund in May 2021. This is the decision to invest in the second BIS green bond fund that reflects its commitment to sustainable investment practices and addressing the implications of climate change.

The Reserve Bank of New Zealand (RBNZ) has reaffirmed its commitment to addressing climate change through its Climate Change Strategy. As part of this strategy, the RBNZ has invested US$100 million in green bonds through the BIS investment pool, known as BISIP G1. This investment pool focuses on green bonds issued by sovereigns, agencies, supranational entities, and covered bond issuers that meet the Green Bond Principles and Climate Bond Standards. Additionally, these bonds must have a minimum issuer rating of A- or have a covered bond program with a minimum rating of A-. Furthermore, RBNZ has funded the investment from its foreign reserves portfolio in alignment with its main functions - including monetary policy objectives and the maintenance of orderly markets.

In conclusion, there is an evident and growing trend among central banks to prioritize sustainable finance by considering investments in green bonds and integrating Environmental, Social, and Governance (ESG) as well as Socially Responsible Investment (SRI) principles into their investment objectives. This trend reflects the increasing recognition among central banks of the critical importance of addressing climate change and promoting sustainable practices. Several central banks have already taken proactive steps by incorporating green bonds and sustainable investment practices into their portfolios. These measures not only align with global efforts to combat climate change but also serve as role models for other central banks to follow. Given the significant role central banks play in the global financial system, their involvement in promoting green finance represents a substantial shift towards a more sustainable and responsible approach to investing.

In this context, NBC can align itself with international trends and demonstrate its commitment to environmental stewardship as this central bank has demonstrated its commitment to addressing climate change effects and promoting green finance and sustainable investments. NBC became a member of the Advisory Committee of the Bank for International Settlements (BIS) open-ended fund for central bank investments in green bonds. This fund aims to meet the growing demand for climate-friendly investments among its member institutions and assists central banks in incorporating environmental sustainability objectives in managing their reserves. NBC also

allocated funds from its foreign reserves to this investment, underscoring its commitment to green and sustainable investments.

To further contribute to climate change mitigation and support green finance, NBC joined the NGFS alliance in 2020. Additionally, in 2022, NBC became a member of the BIS Asian Green Bond Fund, which is dedicated to financing green projects in the Asia-Pacific region. These initiatives demonstrate NBC's proactive approach to addressing climate change and its inclusion of ESG considerations in its investment guidelines. Notably, NBC's involvement in these funds indicates its commitment to allocating funds from foreign reserves to ESG or green bonds. Therefore, it would be prudent for NBC to consider and align with this global trend, utilizing its foreign assets to support sustainable investments.

IV.2. Acknowledgement of Climate Change Impacts

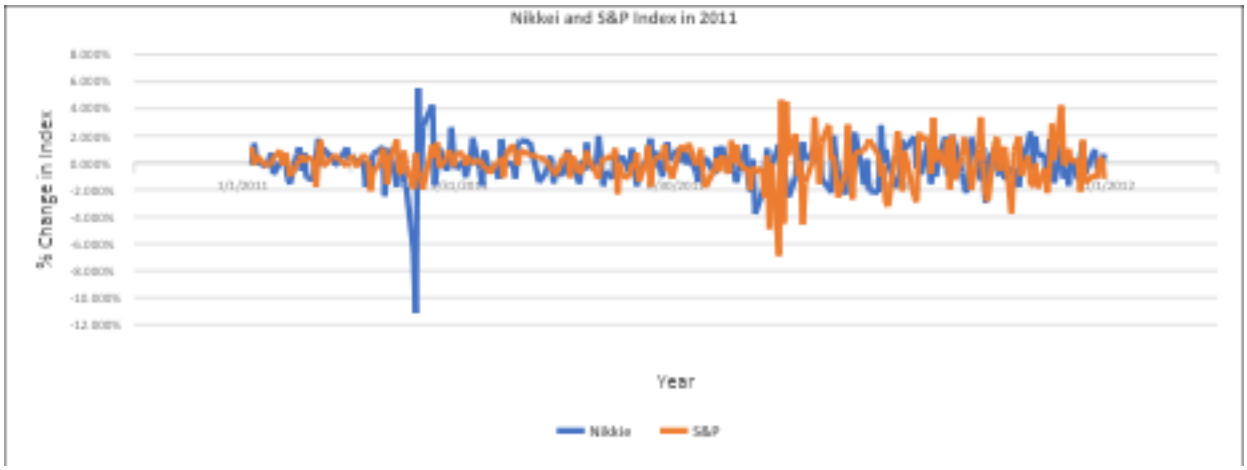
Central banks have gained more understanding of climate change and its impacts. Physical and transition risks can have more impacts on the economy and financial market. These impacts will neither directly nor indirectly cause the valuation of assets, and declining price of assets that are linked to climate change risk.

Several studies can prove and motivate central banks to understand climate change. Grippa et al. (2019) and Gelzinis and Steele (2019) concur that central banks have indeed gained a deeper understanding of climate change and its impacts on the economy and financial markets. Central banks also recognize that both physical and transition risks associated with climate change can have significant consequences for various sectors. These risks can affect the valuation of assets and lead to declining asset prices that they invested in.

According to NGFS (2019), the cost of natural disasters has exceeded the 30-year average of USD 140 billion per annum in 7 of the last 10 years, with extreme weather events increasing since the 1980s. In addition, the U.S. experienced 18 separate billion-dollar weather or climate disasters in 2022, costing $165 billion in damages. Furthermore, according to the National Oceanic and Atmospheric Administration, the disasters were also deadly, causing at least 474 direct or indirect fatalities. The physical impact, including natural disaster events (flood, drought, hurricane), significantly impacts the economy and financial system. The disastrous events cause damage to properties, infrastructure, human lives, businesses, and other economic activities. These are such substantial economic and financial losses.

Additionally, the impacts of the tsunami in Japan are also another evidence to prove the cause of climate change to the economy and financial market. Tsunamis, being natural disasters, can have a significant impact on the Japanese stock market. The occurrence of a tsunami can lead to various consequences, including damage to infrastructure, loss of lives, and economic disruption. Tsunamis can have immediate market reactions; for example, the Japanese stock market has experienced significant volatility and declines in stock prices. The Nikkei 225 fell by 7.5% in the days following the Kobe earthquake in 1995 (Treanor and Webb,2011). Then after the 2011 earthquake and tsunami, the Tokyo stock market plummeted by almost 20% in the first two business days, according to the BIS Quarterly Review (2011).

Graph 1: Movement of Nikkei and S&P Index in 2011 (Japan's 2011 Tohoku earthquake)



Source: Bloomberg Finance

Therefore, central banks acknowledge the significant implications that both physical and transition risks associated with climate change can have on various sectors. These risks have the potential to adversely affect asset valuation, resulting in the devaluation of assets linked to climate change risk. Additionally, the occurrence of natural disasters, such as extreme weather events and tsunamis, can trigger immediate market reactions, leading to substantial volatility and declines in stock prices. These impactful consequences serve as warning signals for central banks, including NBC, to remain cautious and develop strategies for effectively managing these risks and their associated impacts.

In this context, NBC recognizes the significance of climate change and is actively exploring the feasibility of incorporating ESG and SRI principles into its investment framework. NBC is also considering investing in climate bonds for its own portfolio. His Excellency Dr. Chea Chanto, the honorable governor of NBC, emphasizes the central bank's crucial role in mitigating climate change risks that can have far-reaching effects on financial stability. Dr. Chanto further encourages other financial institutions to join in and contribute to these efforts. Additionally, Her Excellency Dr. Chea Serey, the Governor of the NBC, underscores the central bank's role as a role model in establishing policies and frameworks that aid in mitigating climate change risks.

As highlighted in the IMF Article 4 report of 2022, Cambodia is particularly vulnerable to climate risks, including floods, droughts, and storms. From 1993 to 2020, the country experienced 20 floods, five droughts, six tropical storms, and one famine, resulting in estimated damages of at least US$1.5 billion. The impacts of these events underscore the importance of regular monsoon seasons and the effects of fluctuations in Mekong River flows on traditional irrigation, fishing, and transportation.

Given the need to address and mitigate climate change risks, the Cambodian government, policymakers, relevant authorities, and other stakeholders are coordinating their efforts. NBC, as one of the relevant authorities, plays a crucial role in directly or indirectly contributing to climate change risk prevention. Leveraging its authority under existing laws, NBC can promote ESG practices. By incorporating ESG considerations into its foreign reserve management, the NBC

can contribute to sustainable development and resilience-building efforts in the face of climate change.

IV.3. Diversification Perspective

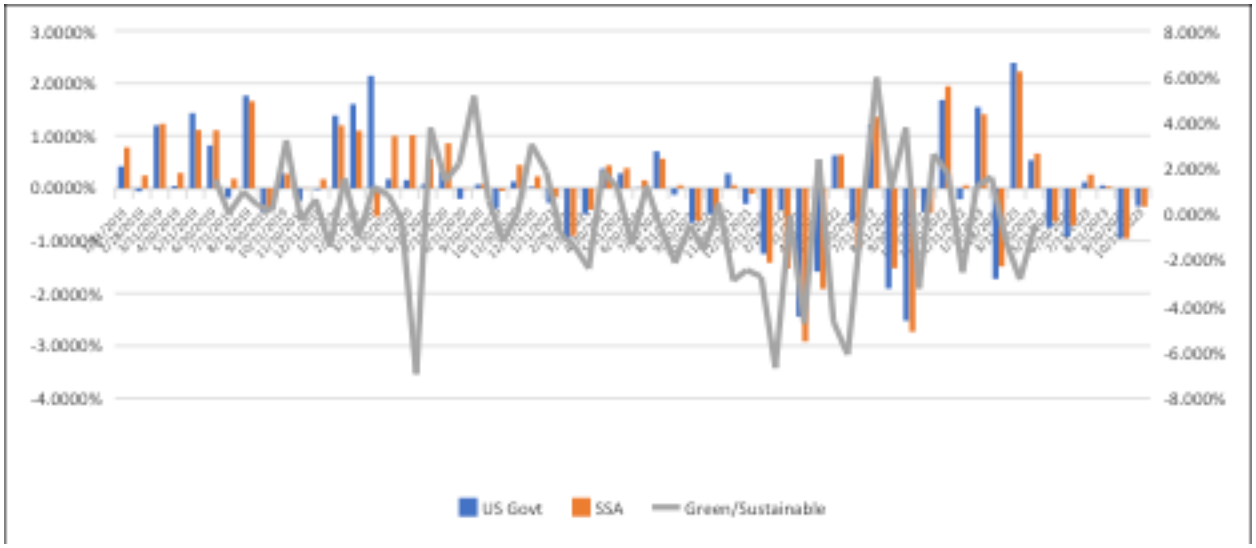
In this context, investors believe that investment in green bonds can be a proper diversified strategy. According to Giugale (2018), Investing in green bonds can provide diversification benefits to an investment portfolio. By including green bonds alongside other asset classes, investors can spread their risk and potentially enhance their overall portfolio performance. In addition, according to the ADB (2022), investors are motivated to invest in green bonds to diversify their investment portfolios and improve their green image as well as to diversify their investment holdings and align their portfolio with sustainable and environmentally friendly projects.

The study explores the correlations between three bond indices: the US Treasury bond index, the government-related bond index, and the global green and sustainable bond index. The US Treasury bond index consists of US government bonds denominated in US dollars, the government-related bond index consists of sovereign supranational, and agencies (SSA) bonds denominated in US dollars, and the global green and sustainable bond index consists of global corporate bonds and SSA bonds denominated in US dollars and issued for funding green and sustainable projects (ESG and SRI related).

Table 1: Correlation between US treasury, Government-Related, and Global Green and Sustainable Bond

	US Treasury	Government-Related	Green and Sustainable
US Treasury	1.00		
Government- Related	0.89	1.00	
Green and Sustainable	0.56	0.80	1.00
Source: Bloomberg and Exchange Management Department (NBC)			

Graph 2: Returns of US treasury, Government-Related, and Global Green and Sustainable Bonds January 2019- October 2023



Source: Bloomberg and Exchange Management Department (NBC)

According to the study, the statistical outcome shows that these three bond indices are positively correlated with each other (Table 1 and Graph 2). The correlation between the US treasury and the Green/Sustainable bonds is 0.56, indicating that both are positively correlated; however, there is less correlation compared to the US treasury bonds and Government-Related bonds (correlation is 0.89). Even though there is less correlation, the positive correlation also means that the price movement of all bonds in these indices is in the same direction.

In conclusion, while the statistical result suggests that there is less diversification to investing in green bonds, several studies and surveys conducted by international institutions indicate a belief in the diversification benefits of green bonds. Diversification is a widely recognized principle in investment management, and green and sustainable bonds can provide an additional avenue for diversification within the bond market. Overall, investors should consider their investment goals and assess the potential diversification benefits of green bonds in their specific circumstances.

In this context, NBC recognizes that investing in green and sustainable bonds can offer diversification benefits, despite the positive correlation that may exist between conventional and green bonds. By incorporating these bonds into its investment portfolio, NBC can potentially reduce its reliance on traditional assets and mitigate risk. This diversification can lead to improved risk-adjusted returns for the bank. By including green and sustainable bonds in its investment strategy, NBC aims to reduce its exposure to conventional assets, while also contributing to environmental sustainability and promoting responsible investment.

IV.4. Return Perspective

Return is indeed a key aspect when making investment decisions, and it is important to consider the potential financial returns of green bonds. While financial returns can vary, green bonds have the potential to offer competitive returns that are comparable to conventional bonds.

As the demand for green bonds increases, issuers may be incentivized to offer attractive interest rates to attract investors. This is because the market for green bonds is expanding as more investors seek to align their investments with environmental and social objectives.

The attractiveness of the interest rates offered on green bonds can be influenced by several factors. For instance, issuers may benefit from positive market sentiment towards sustainable investments, which can result in increased demand for green bonds. To meet this demand, issuers may offer competitive interest rates to make their green bonds more appealing to investors. Furthermore, the growing interest in sustainable finance has led to the development of frameworks and standards for green bond issuance. These frameworks provide guidelines for the use of proceeds and ensure transparency and accountability in the allocation of funds towards environmentally friendly projects. This increased standardization and transparency can help build investor confidence and contribute to the attractiveness of green bonds.

In conclusion, green bonds have the potential to offer competitive returns that are comparable to conventional bonds (nongreen or sustainable bonds). As the demand for green bonds increases, issuers may offer attractive interest rates to attract investors. However, investors need to conduct thorough due diligence and consider other factors such as market conditions and individual issuer performance when evaluating the potential financial returns of green bonds. In addition, it is important to note that the perceived return benefits of green and sustainable investments may vary, and actual returns may move in a different or even opposite direction from what investors anticipate.

In this context, NBC can access new investments from the fast growth of the green bond market. This development and growth of this market will offer a wide range of investment opportunities and potentially generate attractive returns.

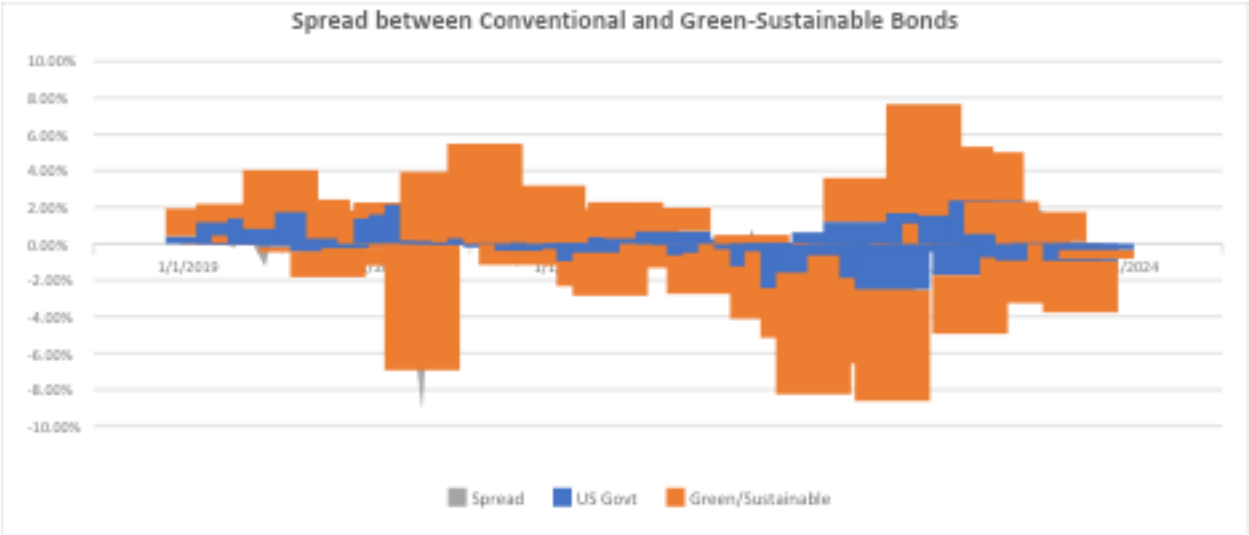
V. Challenges

This section will address the key challenges that central banks may encounter when considering a transition from conventional bonds to green and sustainable bonds. Two primary challenges arise in this context: the costs associated with adopting green and sustainable bonds, and the issue of liquidity. These challenges pose significant considerations for central banks as they navigate the potential shift towards green and sustainable investments.

V.1. Potential Costs of Turning to Green or Sustainable Bonds

Strategic decisions are influenced by both benefits and costs, and the transition to green and sustainable bonds is no exception. While there are potential benefits associated with moving towards these investments, there are also costs involved in the switch. One consideration is that green or sustainable bonds may offer slightly lower yields compared to similar conventional bonds, which some investors argue is due to the "greenium" effect. The "greenium" represents the premium that investors are willing to pay for the environmental benefits associated with green bonds. This yield difference arises because investors must give up their existing conventional bonds, potentially even a portion or the entirety of their portfolio, to invest in green and sustainable bonds.

Graph 3: Spread between Conventional and Green-Sustainable Bonds



Source: Bloomberg and Exchange Management Department (NBC)

Analyzing the cost of transitioning from conventional to green and sustainable bonds can be achieved by examining the spread between selling conventional bonds and purchasing green and sustainable bonds. Graph 3 illustrates the returns of conventional bonds, green and sustainable bonds, and the spread between the two from January 2019 to October 2023. Notably, the spread is predominantly negative, indicating that the return on investing in green and sustainable bonds is generally lower than that of investing in conventional bonds. This finding challenges the perception discussed in section 4.4 that investors anticipate comparable returns when investing in green and sustainable bonds.

To assess the cost of switching, this study will establish a model portfolio and apply the mean-variance optimization (MVO) approach to create an efficient frontier for foreign assets managed by the central bank. The research will utilize various data and indices to analyze correlation and covariance, enabling the construction of a portfolio based on MVO principles. Initially, the portfolio will consist of 10% Cash, 70% US Treasury bonds, and 20% Government-related bonds (SSA), aligning with the central bank's investment objectives, which prioritize maintaining a higher proportion of liquidity assets. Additionally, the study will evaluate the feasibility of incorporating green bonds into the portfolio. By utilizing solvers, the research aims to maximize returns while minimizing risk. The findings will provide insights into whether green bonds are a suitable investment for the central bank, or if they serve other purposes beyond the objectives of return and diversification.

Table 2: Model Portfolio Asset Allocation

Model Portfolio: Asset Allocation	Weight	Annualized Return*	Annualized Volatility**
Cash (USD)	10%	1.74%	1.82%
US Treasury Bonds	70%	0.19%	3.51%

Government-Related Bonds (USD)	20%	0.49%	3.57%
Model Portfolio Total Return		**0.40%**	
Model Portfolio Total Risk			**0.46%**
Return (Average Monthly Return from January 2019-October 2023) and Cash Rate applied Average monthly FED FUND Effective from January 2019-October 2023* * Volatility is the standard deviation of monthly return from 2019-2023* Source: Source: Bloomberg and Exchange Management Department (NBC)			

Table 2 presents the model portfolio, which comprises cash, US Treasury bonds, and government-related bonds, detailing the proportion and returns of each asset class. The model portfolio demonstrates an annualized total return of 0.40% and a total risk of 0.46%. These figures provide a comprehensive overview of the performance and risk profile of the portfolio.

Incorporating a new asset class, Global Green and Sustainable Bonds, into the existing model portfolio will be a key focus of this study. The Microsoft Excel Solver function will be leveraged to determine the optimal proportions that maximize the total return of the new model portfolio. However, certain constraints will be applied during the asset allocation process. These constraints include maintaining a minimum of 50% and a maximum of 70% allocation to US Treasury Bonds, a minimum of 5% and a maximum of 10% allocation to Cash, and a maximum allocation of 20% to both Government-related and Green and Sustainable bonds. These limitations are designed to uphold a higher level of liquidity in line with the investment objectives. Additionally, there will be a minimum requirement of 5% allocation to Green and Sustainable bonds to reflect the intention of investing in ESG, while also ensuring that the proportion of spread products is maintained at 20%.

Table 3: Risk and Return Characteristics of Assets

Asset Classes	Return*	Volatility**
Cash (USD)	1.74%	1.82%
US Treasury Bonds	0.19%	3.51%
Government-Related Bonds (USD)	0.49%	3.57%
Green and Sustainable Bonds (USD)	-1.62%	9.10%
Return (Average Monthly Return from January 2019-October 2023) and Cash Rate applied Average monthly FED FUND Effective from January 2019-October 2023* * Volatility is the standard deviation of monthly return from 2019-2023* Source: Source: Bloomberg and Exchange Management Department (NBC)		

Table 4: New Model Portfolio (Included Green and Sustainable Bonds as compulsory)

Asset Classes	New Allocation	Return*	Volatility**
Cash (USD)	**10%**	1.74%	1.82%
US Treasury Bonds	**70%**	0.19%	3.51%
Government-Related Bonds (USD)	**10%**	0.49%	3.57%
Green and Sustainable Bonds (USD)	**10%**	-1.62%	9.10%
New Model Portfolio Expected Return and Risk	**100%**	**0.19%**	**0.51%**

**Return (Average Monthly Return from January 2019-October 2023) and Cash Rate applied Average monthly FED FUND Effective from January 2019-October 2023*
*** Volatility is the standard deviation of monthly return from 2019-2023*
Source: Source: Bloomberg and Exchange Management Department (NBC)

Table 4 presents the results of applying the MVO approach to allocate funds, aiming to generate maximum returns. The new asset allocation includes Cash (with an unchanged weight), US Treasury bonds (with an unchanged weight), Government-related bonds (reduced from 20% to 10%), and Green and Sustainable bonds (included at 10% based on the compulsory investment requirement). Consequently, the total expected return of the new model portfolio is 0.19%, significantly lower than the return generated in the previous model portfolio (Table 2: Expected return of 0.40%). Moreover, the total risk increases from 0.46% (Table 2) to 0.51% (Table 4). These findings highlight the trade-off between maximizing returns and managing risk in the context of the new asset allocation strategy.

In conclusion, it is important for investors to carefully consider the cost of transitioning from conventional to green and sustainable bonds, as evident from the results of the new model portfolio. The observed decrease in return and increase in risk highlight the potential trade-offs involved in making such investment decisions. Investors must weigh the potential environmental and social benefits of green and sustainable bonds against the financial implications. While there is a growing emphasis on sustainable investing, it is crucial to thoroughly evaluate the impact on returns and risk before making any significant portfolio adjustments. A comprehensive analysis of the potential benefits and drawbacks can guide investors toward making informed decisions that align with their investment objectives and values.

In this context, if NBC decides to transition from conventional bonds to green and sustainable bonds, there is a possibility of incurring losses. Currently, the majority of NBC's portfolio consists of conventional bonds, while only a small portion is allocated to green bonds (specifically, those within the BIS Investment Pools.

To make the switch, NBC would have to sell its existing conventional bonds, potentially at a loss because of the higher yield environment. This means they might not get back the full amount they initially invested. Additionally, when purchasing green bonds, NBC may face the "greenium" effect. This means they would have to sell higher-yielding conventional bonds to buy lower-yielding green bonds. This could result in sacrificing higher returns for lower returns.

Overall, NBC may incur losses due to selling conventional bonds at a disadvantageous time and potentially facing a trade-off between higher returns from conventional bonds and lower returns from green bonds.

V.2. Liquidity Constraints

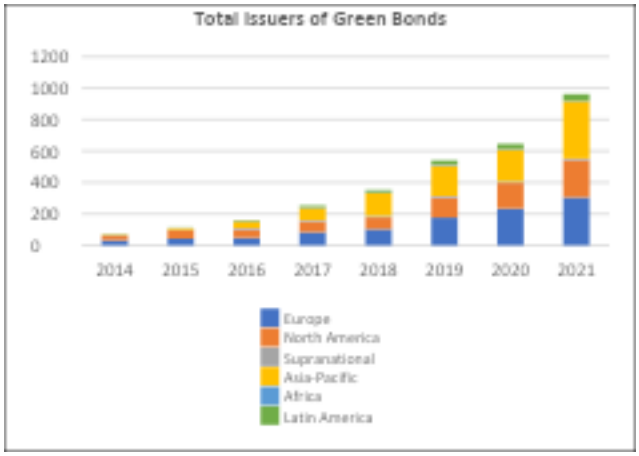
Liquidity is also an important objective for central banks in managing their foreign assets, and it applies to investments in green and sustainable bonds as well. For these investments to be effective, the market for green and sustainable bonds must be sufficiently liquid. This means that investors can readily buy and sell these bonds in the market, with the bid-ask spread being relatively like conventional bonds.

To assess the liquidity condition of green and sustainable bonds, this study will analyze the market of green and sustainable bonds. According to Fender et al. (2019), outstanding green bonds are relatively smaller than comparators, known as conventional bonds, and most issuers are government and international institutions. Since the size of the market is smaller, there are seemingly increasing demands from investors in both primary and secondary markets. In addition, investors intend to buy and hold these bonds to maturity. Therefore, there is a limitation of green bonds available in the market unless there is no additional supply.

However, there is also an increasing supply of green bonds to match up oversubscription from investors. According to the Climate Bond Initiative, there are 966 issuers of green bonds (from developed and emerging countries and supranational), equivalent to USD 578.4 billion in 2021 (Graph 4&5). Those issuers are from Europe (305), Asia-Pacific (364), and the rest from North America and Latin America (281). Green bonds the significant currencies of the green bonds were EUR (43%), USD (26%), CNY (11%), GBP (6.17%), and the rest of the currencies, such as SEK, CAD, SGD, JPY, AUD, and others (Graph 6). Although the EUR has played the most significant role in the green bond market, the USD has dominated the most important deals of green bonds (Graph 7).

Graph 4: Issuers of Green Bonds

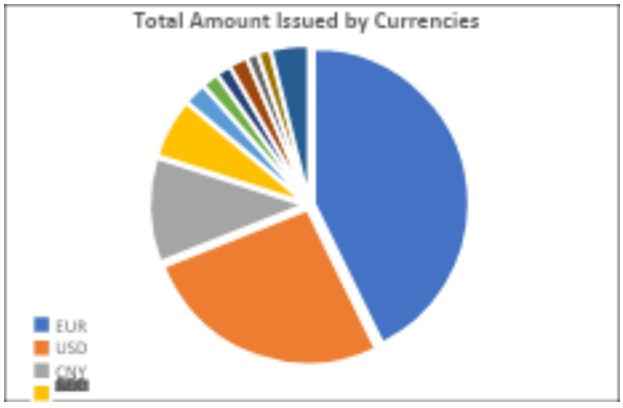
Graph 5: Total Amount Issued of Green Bonds

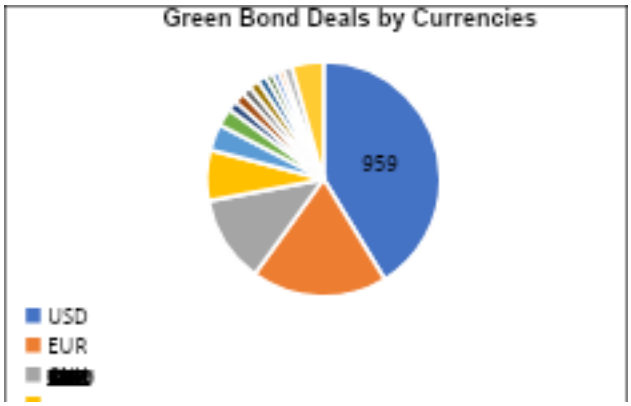


Source: Climate Bond Initiative

Graph 6: Currencies of Green Bonds

Graph 7: Deals of Green Bonds by Currencies





Source: Climate Bond Initiative

The market size of green bonds, although growing rapidly, is still relatively smaller compared to conventional bonds. In 2021, there were 966 issuers of green bonds, with a total value of approximately USD 578.4 billion. While this represents a substantial amount, it indicates that the market for green bonds is not yet as large as the market for conventional bonds.

Bos (2023) supports Fender et al. (2019) and agrees with the current trend of green bond issuances (Climate Bond Initiative), highlighting that the overall size of the green bond market may remain smaller when compared to other bond markets. Despite being one of the fastest-growing segments in the fixed-income market, especially over the past five years, green bonds have yet to reach the same scale as their conventional counterparts. Indeed, the green bonds market is still smaller than the conventional bonds market which presents liquidity constraints to investors to make decisions to invest in these bonds.

Another approach to measure liquidity is to analyze the bid-ask spread. Like conventional bonds, a wider bid-ask spread indicates a lack of liquidity as this bond is harder to sell and buy. smaller bid-ask spread indicates the higher liquidity of this bond in the market. Fender et al. (2019) examined the bid-ask spread of green bonds and concluded that the bid-ask spread for green bond trading is wider, indicating that it is more costly to buy and sell these bonds in the market. This suggests that green bonds may have lower liquidity compared to conventional bonds.

In summary, two major liquidity constraints can discourage investors from investing in green and sustainable bonds a smaller market size compared to conventional bonds market even both

primary and secondary markets, and a wider bid-ask spread compared to conventional bond trading. Liquidity is most important for investors, particularly central banks which prioritize liquidity as a core investment objective. Therefore, the less liquid market of these green and sustainable bonds will pose a major constraint in the decision-making process.

In this context, NBC is like other central banks to prioritize the importance of liquidity. NBC must maintain sufficient liquidity by investing in liquid assets such as cash, short-term deposits, treasury bills, and government bonds. While central banks attempt to maintain liquidity, investing in green and sustainable bonds presents certain challenges. These bonds are issued to fund environmentally friendly projects and initiatives, and their popularity has been increasing in recent years. However, compared to traditional liquid assets, green and sustainable bonds pose specific obstacles in terms of market size and bid-ask spread.

By given these challenges, central banks might face a trade-off between maintaining liquidity and supporting green initiatives. While investing in green and sustainable bonds aligns with environmental goals, it may compromise the central bank's ability to ensure sufficient liquidity. Therefore, central banks must carefully assess the potential impact on overall portfolio performance and liquidity management when considering investments in green bonds.

VI. Conclusion

Through its journey of investing in green and sustainable bonds, NBC has gained valuable insights and lessons that can guide its future endeavors in sustainable and green financing.

Firstly, NBC has learned that a clear and strong motivation for investing in green and sustainable bonds is essential. By recognizing the environmental and social benefits of investment in green and sustainable bonds, NBC has set its commitment to promoting sustainable development, green finance, and addressing pressing environmental challenges. This motivation serves as a guiding principle for NBC to act and make decisions in the realm of sustainable financing.

Lastly, NBC has come to understand that transitioning from conventional bonds to green and sustainable bonds involves certain costs. These costs can be financial, operational, and even cultural. However, NBC has learned that the long-term benefits, both for society and the environment, compensate for these costs. By embracing the transition and investing in sustainable financing, NBC can contribute to a more resilient and sustainable economy for Cambodia and the globe.

Therefore, NBC has learned that a strong motivation and careful consideration of costs are key factors in successfully implementing sustainable financing initiatives. By justifying the benefits and costs of moving from conventional to green and sustainable bonds, NBC can make better investment decisions that focus on long-term benefits, especially those linked to environmental and social support rather than incurred costs. In addition, this cost can be covered in the long run, consequently, NBC can receive dual benefits in terms of income generation and environmental and social support.

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