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Environmental risk management of the international reserves: an applied framework discussion with the Central Banks from Latin America and the Caribbean

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Abstract

This is an applied framework discussion with central banks (CBs) from Latin America and the Caribbean (LAC) regarding the environmental risk management (ERM) of the international reserves (IRs). This study is based on a sample of CBs from LAC, taking into consideration the national exports of the respective countries, the risk of sudden stops in capital flows and the IRs' economic objectives. Commodities are economically relevant for all analyzed countries. The specific environmental risk exposures are discussed, as are the alternatives to ERM through the IRs' strategic asset allocation (SAA). The framework discussed herein includes environmental risk analysis (ERA) in the IRs' traditional SAA approach. As a result, IRs investments can become more resilient to environmental and climate risk exposure.

Keywords: environmental risk management; central banks; international reserves; Latin America and the Caribbean.

This study represents the authors' understanding, not any institutional´s one.

SUMÁRIO

1.   INTRODUCTION

Environmental factors result in a range of financial risks that have important implications for investments. To manage risks, they must be identified and measured. Environmental risk management (ERM) is a challenge for investors, including central banks (CBs), when they act as managers of international reserves (IRs).

IRs are investments held by CBs in foreign currencies to implement monetary and foreign exchange (FX) policies (Hawkins and Rangarajan, 1970; Detragiache, 1996; Aizenman and Marion, 2002; Allen et al., 2002; Kohlscheen and O'Connell, 2004; Silva Jr., 2011). Thus, they are classified in the policy portfolios of CBs (NGFS, 2019). IRs' economic objectives include intervention in the FX market, execution of payments for goods and services, execution of payments for the government, granting of emergency liquidity assistance, underpinning investors' confidence in the country, and investment of excess reserves (Fender et al., 2019). For these and related reasons, IRs totaled US$13.978 trillion in 2019 (The World Bank, 2020).

In emerging markets such as Latin America and the Caribbean (LAC), IRs provide two important and widely accepted functions for CBs: self-insurance (Calvo and Loo-kung, 2012) and warning signaling (Kaminsky et al., 1998). Avoiding environmental risks, such as climatic ones, is compatible with these two rationales.

Environmental risks are also important for CBs' other monetary policy implementation instruments (McKibbin et al., 2020), as well as for other key tasks, such as financial stability maintenance (Roncoroni et al., 2021). In some climate policy scenarios, effects in sectors as energy and utilities may lead to systemic losses and threaten financial stability (Roncoroni et al., 2021). On the monetary policy side, policy responses to climate change, such as carbon emission targets, may lead to negative supply shocks and affect CBs' ability to forecast and manage inflation (McKibbin et al., 2020). Our discussion of ERM occurs in this context and makes the case for a new IR management framework, mainly due to the perceived urgency of the climate action and possible short- and medium-term transition effects.

In this context, and in the search for contributions to this knowledge gap, this is an applied framework study of CBs from LAC aimed at the ERM of the IRs. The research question was as follows: What are the relevant environmental risk exposures to the management of the IRs from LAC, taking into consideration the economic objectives of the IRs and the risk of sudden stops in capital flows based on the respective national exports? In addition, how could the ERM be performed through the IRs' strategic asset allocation (SAA)?

The methodology used in this work included literature and desk reviews, data analysis for ten CBs from LAC, a questionnaire, and meetings that included discussions with some selected CBs. The research findings confirmed the economical relevance of commodities for the analyzed countries and the related environmental risk exposure.

Among this study's contributions are discussions of the specific environmental risk exposures of LAC and alternatives to ERM through the IRs' SAA. The framework discussed herein includes environmental risk analysis (ERA) in the IRs' traditional SAA approach. Consequently, the management of the IRs can become more resilient to environmental and climate risk exposure.

The most important distinction of this approach in comparison to a more general ESG[1] investment strategy is that we consider a more macro strategy that considers each country's reliance on certain exports and designs a strategy to deal with sudden stops of such income sources due to environmental factors. This is, to the best of our knowledge, the first time that this exercise has been done for such a variety of countries in a region that is exposed to severe negative impacts from environmental phenomena.

This paper proceeds as follows: Section 2 covers the ERM of IRs through SAA from the discussion of environmental factors as sources of financial risks to the environmentally adjusted SAA framework for IR management. Section 3 presents the methodology of this research with CBs from LAC. Section 4 present the study's results and discussion. The paper concludes in Section 5 with an outlook for future research.

2   ERM OF IRS THROUGH SAA

The IRs must be part of the ERM of CBs, but the question is how this ERM can be performed though SAA of the IRs. The contribution of this section will be to review the environmental factors as a source of financial risks (section 2.1) and to discuss an environmentally adjusted SAA framework for IR management (section 2.2), as follows.

2.1   FROM ENVIRONMENTAL FACTORS TO FINANCIAL RISKS

Environmental factors include climatic, geologic and ecosystem dimensions. Climatic factors imply the presence of physical and transition[2] climate risks. Climate risks lead to financial risks through micro and macroeconomic transmission channels. Some examples include property damage and business disruptions due to extreme weather events, stranded-assets due to changes in policy or technology, price shifts due to supply shocks, and exchange rate volatility due to changes in capital flows. These impacts of the sources of different types of financial risks, including credit, market, underwriting, operational, and liquidity risks (NGFS, 2020).

The environmental physical risks and associated transition risks may increase market volatility and sector instability, driving potential financial losses (Roncoroni et al., 2021). For instance, physical shock events, such as natural disasters, might impact corporate finances. In addition, changes in trends such as water scarcity, extreme weather events, air pollution, and natural capital degradation represent risks to corporate sectors such as agriculture and power generation.

LAC may be severely impacted by climate change (Burke et al., 2015; Mora et al., 2017; Bolton et al., 2020; Woetzel et al., 2020). Humans may have to abandon many areas, and entire regions of South America and Central America could become uninhabitable due to a mixture of high temperatures and humidity levels (Mora et al., 2017; Bolton et al., 2020). Heat stress and a drought risk area are projected for the majority of LAC (Woetzel et al., 2020). Finally, the change in GDP per capita by

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1   ESG investment: investments which incorporate environmental, social and governance factors in the decision--making process.
2   Transition climate risk: the risk that results from changing policies, practices, and technologies towards a low--carbon future.
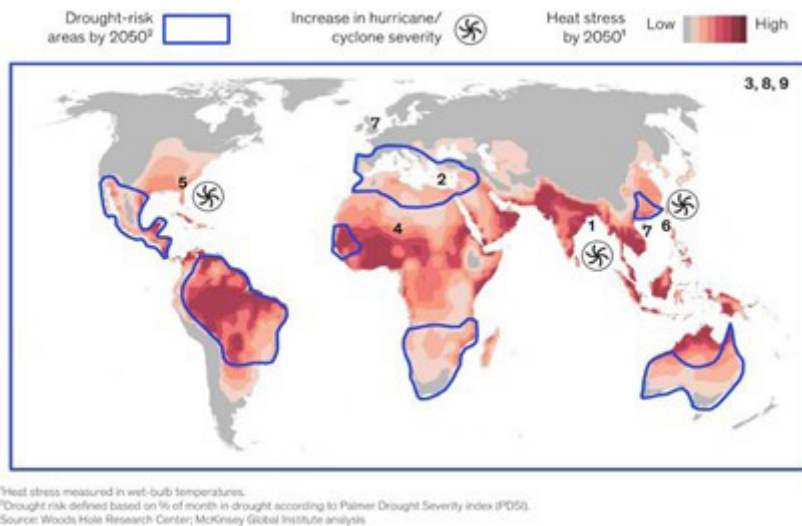
2100 compared to a world without climate change might be minus 100% for many countries in LAC (Burke et al., 2015).

Figure 1 - Average temperature change in different IPCC (Intergovernmental Panel on Climate Change) global warming scenarios.
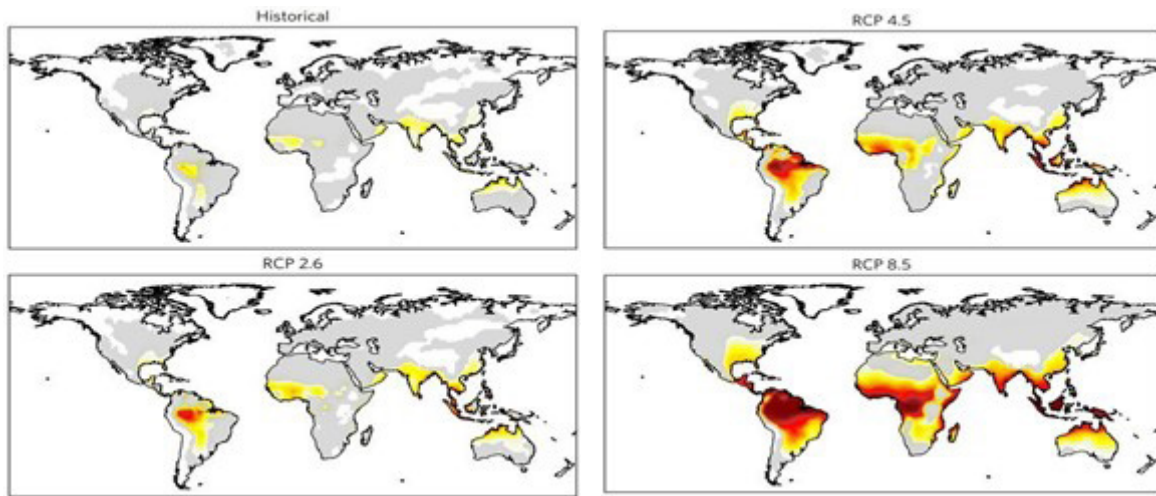
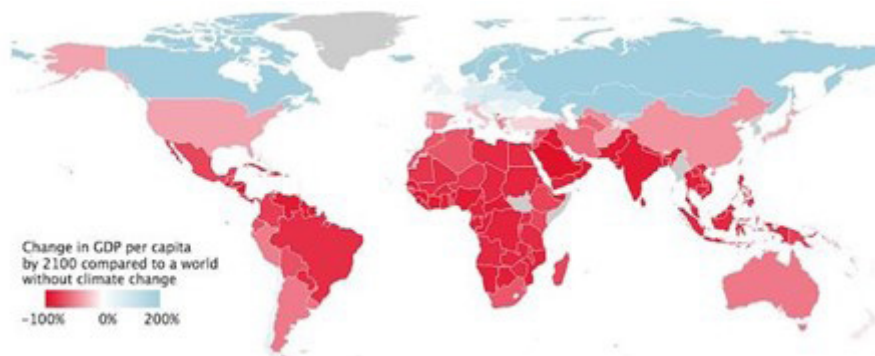Source: Mora et. al. (2017, fig. 3) e Bolton et. al. (2020, fig. 2)

Figure 2 - Heat stress and drought risk.

Source: Mora et. al. (2017, fig. 3) and Bolton et. al. (2020, fig. 2)

Figure 3 - Change in GDP per capita by 2100 compared to a world without climate change.

Source: Burke, Hsiang and Miguel (2015, fig. 4a)

Most LAC countries are economically based on the agriculture and energy sectors. As forese-

en in previous figures and in the climatic projections (IPCC, 2014), agriculture may be significantly impacted by new drought areas and changes in precipitation patterns and, consequently, in agricultural areas. In addition, impacts come from policies and economic preferences towards biodiversity preservation, as well as changes in food preferences, including the increase in veganism motivated by environmental discussions worldwide.

In addition, worldwide policy efforts to achieve a low-carbon economy significantly and even disruptively affects virtually all industries and sectors in the medium and long terms (TCFD, 2017), particularly the energy sector. Carbon pricing systems are already stimulating the alignment of the energy market with green public policies, and changes to the energy matrix that incorporate clean technologies already exemplify potential medium-term developments and impacts. All this has important implications for transition risks and stranded assets (Caldecott et al., 2014), which could also have implications at the national level for many LAC countries.

The 2021 Leaders' Climate Summit brought together the main global leaders and sent two important signals: concern about the physical risks associated with climate change, such as the increased incidence of natural disasters; and the risk that companies will have stranded assets that are not realizable due to the transition to low-carbon energy sources. As Kristalina Georgieva, head of the International Monetary Fund (IMF), highlighted:

> We have to make the invisible visible – the transition risks that banks are carrying because they're investing in high-carbon activities that over time are going to be phased out, and the physical risk, investments in highly vulnerable coastal areas, or in agriculture that could be affected by floods or by droughts" (Shalal, 2021, 1).

Thus, the environmental risks, including the climatic ones, are relevant sources of financial risk that impact the performance of investments. As a result, the ERM of IRs is important for CBs and includes risk identification, measurement, and control, taking into consideration environmental externalities, trends, and events (Cambridge Centre for Sustainable Finance, 2016; Bank of England et al., 2017; TCFD, 2017).

2.2   IRS management by CBs

The objectives of IR management vary among CBs and portfolios under the same investment manager. For some, the main objective is to hold liquid and safe foreign exchange (FX) assets for interventions within monetary policy implementation duties. For others, it is capital preservation as fiduciary duty. The objective can also be financial stability through the management of a financial buffer for interventions in financial crises, among other strategies, as inflation management.

According to the IMF's (2020) Assessing Reserve Adequacy (ARA) metrics, 5% to 7.5% of total exports should be covered by IR assets allocated to hedge sudden stops in capital flows.

In crises, IRs are fundamental to quickly mobilizing funds in liquid portfolios (or even investment ones) to meet domestic banks or firms' foreign currency needs and to support the domestic currency's FX value (McCauley and Rigaudy, 2011). Financial stability objectives are an important constraint to IR management, short-term liquidity needs, and reputational concerns

Environmental factors may be behind the next big crisis, which might be related to global

warming, water, or biodiversity stress. For this reason, and for risk–return investment management purposes, ERA should inform IRs' management processes. Risk response management decisions will align the IRs' risk exposure with the CB's risk tolerance and/or facilitate the exploration of opportunities according to the CB's risk appetite. Among possible risk responses, reweighting SAA is an option that does not necessarily imply any green investment strategy.

2.3   ERM through SAA

ERA and ERM are prominently linked to SAA via a common time frame (i.e., the long-term horizon for the assessment). SAA is an investment decision made by asset owners to manage portfolio performance and risk over the long term. However, many investors now face the tragedy of the horizon (Carney, 2015). This means that investors seek short-term returns, but environmental risks have long-term horizons (Carney, 2015). CBs are long-term investors, so the problem of the tragedy of the horizon should be managed via the SAA process.

Different portfolio types have different vulnerability and resilience to environmental and climate change related risks. Each asset class presents different risks and opportunities, demanding a multifaceted strategy across the total portfolio. In turn, the ERA comprises a financial analysis of environmental factors, including pricing and implications for an investment portfolio. Thus, ERA facilitates the integration of environmental data into risk management and asset allocation processes.

It is possible to mitigate environmental risks and to incorporate investment opportunities through assets, regions, sectors, and sub-asset class allocations (PRI, 2019). ERM by investors through SAA may include, for example, increasing asset allocation to climate-sensitive assets as a climate "hedge," as well as using sustainability themed indices in passive portfolios (Mercer, 2011). According to CISL (2015), "short-term shifts in market sentiment induced by awareness of future climate risks could lead to economic shocks and losses of up to 45 per cent in an equity investment portfolio value (23 per cent loss for a fixed income portfolio)." In addition, "around half (53 per cent) of this decline is 'hedgeable' if investments are reallocated effectively, but the other half (47 per cent) is 'unhedgeable,' meaning investors and asset owners are exposed unless some system-wide action is taken to address the risks" (CISL, 2015). For climate hedges, industry-sector impacts are expected to be the most significant (e.g., energy, with significant losses in coal and gains in renewables), and asset class returns impacts could also be material. According to Mercer (2015), a 2°C scenario could lead to better returns for emerging market equities, infrastructure, real estate, timber, and agriculture, whereas a negative impact is expected in a 4°C scenario.

According to Mercer (2015), if more stringent policies are implemented, substantial capital should be made available to assist emerging market countries with farming method adaptations. In addition, Mercer (2015) expects agriculture investments to benefit from technological developments towards more productive and resilient crop varieties. However, agriculture is the asset class that is most negatively sensitive to resource availability, which, in turn, is related to long-term shifts in regional weather patterns and water stress. Finally, over a 35-year period, timber and agriculture were among the asset classes with the potential for the largest positive and negative returns (Mercer, 2015).

In an asset- or portfolio-level risk–return analysis, collinearity and diversification issues should

be taken into consideration at the portfolio level and across various risk profiles to reduce negative impacts. Besides the tragedy of the horizon, the integration of ERA-ERM and SAA has an additional challenge, as there is no guarantee that historical correlations will work on a scenario with an environmental impact. However, investors cannot simply disregard historical information. The integration of ERA-ERM and SAA should analyze environmental factors and optimize risks and opportunities, taking into consideration both problems: the tragedy of the horizon and the weaknesses and strengths of historical data. The integration of ERA into the SAA process may lead to a rebalancing of investments among asset classes in a way that environment risks are considered in the investment scenarios.

It is critical for each CB to assess the level of reliability required for ERA outputs as SAA input, considering the economic objective of the reserves. One can then decide to calibrate which asset class is best suited to the investment pillars (safety, liquidity, return, and maybe sustainability), given the objective of each portfolio and the CB in charge of managing the IRs (Fender et al., 2019).

Some SAA impacts are related to sustainable responsible investing (SRI) strategies in policy and IR portfolios, which include ESG financial (risk–return) and nonfinancial (positive impact) objectives (NGFS, 2020). ERA may be part of this as input in the environmental risk management process, which, in turn, produces an important input for the SAA process: "Protecting portfolios against sustainability risks" and "enhancing risk–return profile" are among the four main reasons CBs adopt SRI investment strategies, along with "mitigate reputational risk" and the desire to "set a good example" (NGFS, 2020, 9).

SAA is one of the possible elements of an ESG integration investment strategy (CFA UK, 2020). In policy portfolios, there is an indication that ESG integration (including financially material ESG criteria in the investment analysis to improve the risk–return profile of the portfolio) has been considered for sovereign, supranational, and agency (SSA) bonds by four CBs, for corporate bonds by two CBs, and for equities by one CB (NGFS, 2020).

According to the NGFS (2021a), the selected stylized options for adjusting operational frameworks to climate-related risks in asset purchases, include tilt purchases and negative screening. Tilt purchases are aimed at biased asset purchases based on climate-related risks and/or criteria applied at the issuer or asset level, whereas negative screening excludes some assets or issuers from purchases if they fail to meet climate-related criteria.

As a case study, the Swedish CB divested from bonds issued by the Canadian province of Alberta and the Australian states of Queensland and Western Australia due to these issuers' large climate footprints (Sveriges Riksbank, 2019). The main motivation behind the Swedish bank's deputy governor's speech was a positive impact action, but this did not exclude eventual ERA considerations. As demonstrated by Battiston and Monasterolo (2020), sovereign bonds' portfolio alignment to a credible 2ºC trajectory can strengthen the sovereign fiscal and financial position by decreasing the climate spread, while a misalignment with a 2°C trajectory can increase it, with financial risk implications for its investors.

Finally, as Volz et al. (2020) stated, CBs "need to understand their exposures to other countries' sovereign risks arising from climate change if they hold those countries' government bonds". Thus, ERA is critical to the SAA of IRs, as IRs are mainly invested in SAA bonds, which are highly exposed

to sovereign risks (Volz et al., 2020), and highly impacted by climatic and other environmental factors.

2.4 ENVIRONMENTALLY ADJUSTED SAA FRAMEWORK FOR IR MANAGEMENT

The environmental risks to which IRs are exposed must be assessed to enable a proper risk management process, including eventual changes in the SAA intended to facilitate the achievement of the CB's objectives. For this purpose, a multicriteria analytical framework was developed to evaluate these environmental risks and their incorporation into the risk management process with outputs to the IR's SAA, as outlined in Figure 4:

Figure 4. Multicriteria analytical framework for ERA and SAA of IR management. Reproduced by permission from Torinelli and Silva Júnior (2021, 8).
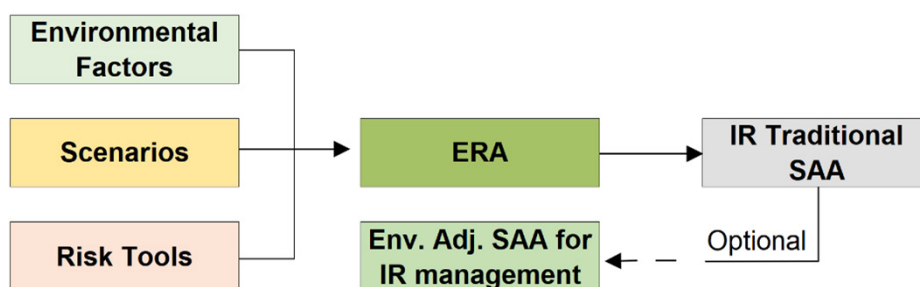
The output of the ERA may provide new information for the IR's SAA framework of IRs (Figure 2) and it will be considered alongside the IR's economic objectives and investment guidelines. Thus, the ERA output will be incorporated in addition to other main concerns of the IR managers, as environmental risk management is not their primary concern. Instead, their primary concern is to adequately address the reasons that motivate the IR's existence (which may vary by CB).

Hence, environmental risk exposure will be considered jointly with concerns about currency, asset type, countercyclicality (for crisis mitigation), and the relevance of each of the three IR investment pillars: security, liquidity, and profitability. The relevance of each pillar depends on the strategic objectives of each IR manager, which ultimately reflect the reasons for which the reserves are being maintained. For example, sovereign wealth funds (SWFs) can prioritize profitability instead of liquidity, whereas emerging countries may need to assign more weight to liquidity and security. This also depends on the objective of each specific portfolio, given that the same investor can prioritize different pillars in different portfolios.

Based on the analysis of the ERA outputs considered in the traditional IR SAA framework, CBs can evaluate the adequacy to adjust the framework to include the environmental factor as a fourth pillar of IR management objectives, which might diversify benefits and improve risk-adjusted returns.

Figure 5. Environmentally adjusted SAA framework for IR management. Reproduced by permission from Torinelli and Silva Júnior (2021, 11), based on Fender et al. (2019) and other references.

IR economic objectives (Fender et al, 2019)	Investment Guidelines	Four pillars of investment	IRs focus (main exposure)	SAA model approaches	Concern for crises mitigation
Intervention in the FX markets; Execution of payments for goods and services; Execution of payments for the government; Granting of emergency liquidity assistance; Support of domestic monetary policy; Underpinning of investor confidence in the country; Investment of excess reserves	Investment Policy; Investment Strategy; Investment Driver; Investment Objectives	Enviromental Sustainability / Profitability / Liquidity / Security	**Asset:** mainly Treasury Bonds, Supranationals, Sovereign Eurobonds, US Agencies, Inflation Protected Bonds, Corporates, MBS/ABS, Covered Bonds, Banks Debt and Green Bonds. **Currency:** mainly USD, EUR, CNY, JPY, GBP.	Mean-variance optimization (MVO), Factor risk allocation, Total Portfolio Analysis, Dynamic asset allocation, Liability driven asset allocation and Regime Switching Models	Countercyclicality

In the above context, environmental risk and opportunities are considered without undermining the perspectives of a particular CB. To better clarify, the purpose of an ERA is to quantify the financial risk exposure related to environmental factors in an IR's assets and portfolios. The purpose of SAA is to identify the best risk–return profile for IR allocation according to IR objectives (i.e., liquidity, safety, return). The combined assessment of financial and environmental risks, as an input for the SAA, may guide IR asset allocation that is sound from these two risk viewpoints. The decision is supported by the CB's risk tolerance and appetite.

Traditional SAA is adjusted to incorporate environmental considerations alongside the traditional investment guidance of IRs as asset classes, currencies, issuers, regions or countries, asset maturity, liquidity (bid-ask spread, turnover), and market depth (outstanding). In addition, specific environmental variables would be included to achieve an efficient investment portfolio, which might require multi-objective optimization.

This investment guidance may direct the partial allocation of the IRs to green assets or indicate a rebalancing among existing assets. Thus, the ERA could measure risks and contribute to reweighting in SAA without necessarily implying any green strategy. Although there is growing pressure for CBs to adopt net-zero strategies (Robins et al., 2021), which are strongly associated with positive impact strategies.

The following are practical possible ERA impacts on an IR's SAA:

1) inclusion of new asset alternatives, such as

    1.1) inclusion of green asset classes (e.g., green bonds, green funds, green indexes in passive portfolios) and

    1.2) inclusion of other asset alternatives, such as unlisted funds, if appropriate for the environmentally adjusted SAA framework;

2) rebalancing among existing asset classes, regions or countries, sectors, and sub asset classes such as

    2.1) divestments from high carbon footprint and/or high-temperature alternatives,

    2.2) investments to explore opportunities to reduce carbon footprints and/or lower temperature options, and

    2.3) migration to assets less correlated with the environmental risks to be mitigated; and/or

3) inclusion of ERM considerations in the selection of asset managers, fund managers, and companies.

3   MATERIALS AND METHODS

This study is based on a sample of ten CBs from LAC. The focus on LAC is based on the relevance of environmental physical and transition risks to the region and the relevance of IRs to regional monetary and FX policies by CBs. The analysis was also part of a common project with the Center for Latin American Monetary Studies (CEMLA).

For the analysis, the sample of ten LAC countries was selected based on the criteria of a GDP higher than US$50 billion for year end 2019 (YE2019) and/or at least 10% of IR on GDP. Ecuador and Panama were excluded due to their lower IRs/GDP (0% and 5%, respectively) and lower IR amounts (US$0.29 and US$3.42 billion, respectively).

Thus, the selected countries were México, Brazil, Argentina, Colombia, Chile, Peru, Jamaica,

Costa Rica, Guatemala, and the Dominican Republic.

Economic data from the respective countries were gathered from the World Bank's public database. IR figures were collected in the public reports of the related CBs. Horizontal and vertical analysis were performed.

Meetings organized by CEMLA were held in February 2021 to discuss the framework with representatives from four out of ten CBs. One of the four CBs answered a detailed questionnaire (Supplementary Material), and a second meeting was held in May 2021 to analyze the application of the framework according to its perceptions and reality. The results are detailed in the following section.

4   RESULTS

A specific exercise was performed with CBs from LAC in the sample detailed in Table 1. LAC IRs for the selected sample totaled US$782.4 billion in 2019, representing 17% of the national GDP and 84% of total annual merchandise exports. Food and agriculture represented 23% of exports, fuel accounted for 9%, and ores represented the other 8%.

Table 1. Applied framework discussion for the analyzed CBS from LAC.

US$ billion in 2019	Mexico	Brazil	Peru	Colombia	Argentina	Chile
IR	183,06	356,89	67,71	52,65	45,22	40,66
GDP	1.258,30	1.839,80	226,80	323,80	449,70	282,30
% IRs/GDP	15%	19%	30%	16%	10%	14%
Total merchandise exports	461,12	222,64	47,77	39,46	65,12	69,68
% IRs/Exports	40%	160%	142%	133%	69%	58%
Food & agriculture raw material exports	35,51	88,83	11,23	7,38	39,98	22,58
% food & agriculture on total exports	8%	40%	24%	19%	61%	32%
Fuel exports	24,44	30,50	3,30	21,58	2,41	0,63
% fuel on total exports	5%	14%	7%	55%	4%	1%
Ores & Metals	8,30	2,89	21,73	0,39	0,33	36,65
% ores & metals on total exports	2%	1%	46%	1%	1%	53%
Manufactures exports	354,60	74,36	4,54	8,33	11,33	9,83
% manufactures on total exports	77%	33%	10%	21%	17%	14%
Total merchandise imports	467,34	184,10	42,26	52,70	49,12	69,59
% IRs/Imports	39%	194%	160%	100%	92%	58%
Food & agriculture raw material imports	25,70	12,70	5,41	7,11	3,68	7,52
% food & agriculture on total imports	6%	7%	13%	14%	8%	11%
Fuel imports	39,26	25,96	6,76	3,64	4,22	11,34
% fuel on total imports	8%	14%	16%	7%	9%	16%
Ores & Metals	8,88	6,44	0,51	0,90	1,23	0,90
% ores & metals on total imports	2%	4%	1%	2%	3%	1%
Manufactures imports	346,30	139,00	29,58	40,58	39,40	49,90
% manufactures on total imports	74%	76%	70%	77%	80%	72%
% IR assets allocated to hedge sudden stops in capital flows (ARA*)	**5%**	**5%**	**5%**	**5%**	**5%**	**5%**
Total IR assets allocated to hedge of the external liabilities related to exports	23,06	11,13	2,39	1,97	3,26	3,48
Hedge for food & agriculture on total exports (e.g.: 40% BR)	**1,78**	**4,44**	**0,56**	**0,37**	**2,00**	**1,13**
Hedge for fuel on total exports (e.g.: 14% BR)	1,22	1,53	0,16	1,08	0,12	0,03
Hedge for ores & metals on total exports	0,42	0,14	1,09	0,02	0,02	1,83
Hedge for manufactures exports	17,73	3,72	0,23	0,42	0,57	0,49
%Hedge for food & agriculture / IRs	1,0%	1,2%	0,8%	0,7%	4,4%	2,8%
%Hedge for fuel / IRs	0,7%	0,4%	0,2%	2,0%	0,3%	0,1%
%Hedge for ores & metals / IRs	0,2%	0,0%	1,6%	0,0%	0,0%	4,5%
%Hedge for manufactures / IRs	9,7%	1,0%	0,3%	0,8%	1,3%	1,2%

* ARA: Assessing Reserve Adequacy - International Monetary Fund (IMF)

Tabela 1 - Applied framework discussion for the analyzed CBS from LAC (continuation).

US$ billion in 2019	Guatemala	Costa Rica	Dominican Rep.	Jamaica	Total
IR	14,78	8,94	8,87	3,63	782,40
GDP	76,70	61,80	88,90	16,50	4.624,60
% IRs/GDP	19%	14%	9,98%	22%	17%
Total merchandise exports	11,19	11,80	1,14	0,17	930,08
% IRs/Exports	132%	76%	781%	2201%	84%
Food & agriculture raw material exports	5,71	5,09	0,33	0,04	216,66
% food & agriculture on total exports	51%	43%	29%	23%	23%
Fuel exports	0,51	0,00	0,00	0,03	83,41
% fuel on total exports	5%	0%	0%	19%	9%
Ores & Metals	0,09	0,17	0,02	0,09	70,67
% ores & metals on total exports	1%	1%	2%	55%	8%
Manufactures exports	4,88	6,54	0,79	0,01	475,19
% manufactures on total exports	44%	55%	69%	3%	51%
Total merchandise imports	19,88	16,15	20,49	6,41	928,06
% IRs/Imports	74%	55%	43%	57%	84%
Food & agriculture raw material imports	3,44	2,26	3,40	1,22	72,45
% food & agriculture on total imports	17%	14%	17%	19%	8%
Fuel imports	3,28	1,63	3,40	1,69	101,18
% fuel on total imports	17%	10%	17%	26%	11%
Ores & Metals	0,24	0,31	0,20	0,02	19,63
% ores & metals on total imports	1%	2%	1%	0%	2%
Manufactures imports	12,88	11,95	13,49	3,48	686,56
% manufactures on total imports	65%	74%	66%	54%	74%
% IR assets allocated to hedge sudden stops in capital flows (ARA*)	**5%**	**5%**	**5%**	**5%**	**5%**
Total IR assets allocated to hedge of the external liabilities related to exports	0,56	0,59	0,06	0,008	46,50
Hedge for food & agriculture on total exports (e.g.: 40% BR)	**0,29**	**0,25**	**0,02**	**0,00**	**10,83**
Hedge for fuel on total exports (e.g.: 14% BR)	0,03	-	0,00	0,00	4,17
Hedge for ores & metals on total exports	0,00	0,01	0,00	0,00	3,53
Hedge for manufactures exports	0,24	0,33	0,04	0,00	23,76
%Hedge for food & agriculture / IRs	1,9%	2,8%	0,2%	0,1%	1,4%
%Hedge for fuel / IRs	0,2%	0,0%	0,0%	0,0%	0,5%
%Hedge for ores & metals / IRs	0,0%	0,1%	0,0%	0,1%	0,5%
%Hedge for manufactures / IRs	1,6%	3,7%	0,4%	0,0%	3,0%

* ARA: Assessing Reserve Adequacy - International Monetary Fund (IMF)

Source: Data from The World Bank (2021).

According to the IMF's (2020) ARA metrics, 5% to 7.5% of total exports should be covered by IR assets allocated to hedge sudden stops in capital flows. In the LAC case, this would account for US$46.50 to US$69.76 billion. Thus, considering the 5% totaling US$46.50 billion, the portion to hedge for food and agriculture on total exports would account for US$10.83 billion (23.29%), fuel would account for US$4.17 billion (9%), and ores and metals would account for US$3.53 billion.

The food and agriculture, fuel, and ores and metals sectors are significantly exposed to environmental risks, including the physical and transition climate ones. This exposure has implications for exports and capital flows, as well as, from this perspective, an indirect impact on IRs. The IRs would be affected in terms of their economic objectives, such as the execution of payments, intervention in

FX markets, and underpinning of investors' confidence in the country.

In an ERA for the IRs of the LAC sample, the relevant economic sectors are food and agriculture, fuel, and ores and metals. The environmental factors could be climatic transition (avoidance of GHG emissions), policy, technology, and sentiment-based or reputational dimensions, besides the physical climatic impacts (temperature and precipitation, as well as extreme events).

The relevant scenarios may contemplate climate-change transition risk and climate- change physical risk, considering, for example, NGFS (2021b) climate scenarios for CBs and supervisors. The related environmental risks, with potential financial impacts for some specific time horizons, could include increased GHG emission costs, assets stranded due to changes in policy and technology toward a more sustainable economy, and crop failures due to physical climate changes.

Some expected asset-price movements in crisis scenarios would reduce country exports and have an impact on the FX rate. The impacts could also be related to stranded assets in the Oil & Gas sector. appreciation of clean energy assets, variation in ore and metal demand due to technological changes, and the transition to a low-carbon economy, as well as potential decreased water availability and increased energy and operational costs, increased commodity prices due to crop failures, a decrease in non-regenerative agriculture average asset prices, stranding of assets related to policy and regulation changes toward biodiversity conservation (e.g., reduction in the legal deforestation zone on agricultural lands), and similar factors. The SAA exercise might consider portfolios for the investment of the IRs that are more resilient to these scenarios.

The IRs allocation in currencies and asset classes YE2019 are detailed in Table 2:

Table 2. IRS allocation in currencies and asset classes for YE2019.

IRs in US$ billion on 2019	MEX		BRA		PER		COL		ARG	
Currencies	183,1	1,0	356,9	1,0	67,7	1,0	52,7	1,0	44,9	1,0
U.S. dollar	170,0	0,9	309,7	0,9	58,9	0,9	0,0	0,0	0,0	0,0
Euro	-0,1	0,0	26,2	0,1	0,0	0,0	0,0	0,0	0,0	0,0
Pound Sterling	0,2	0,0	7,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Japanese Yen	1,2	0,0	6,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Canadian Dollar	1,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Australian Dollar	0,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
SDR	2,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Singapore Dollar	1,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
New Zeeland Dollar	1,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Offshore Chinese Yuan	1,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Swiss Franc	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other currencies	0,7	0,0	3,9	0,0	6,1	0,1	0,0	0,0	0,0	0,0
Gold	1,2	0,0	3,4	0,0	2,7	0,0	0,0	0,0	0,0	0,0
Asset Class	183,1	1,0	356,9	1,0	67,7	1,0	52,7	1,0	44,9	1,0
Sovereigns	0,0	0,0	325,0	0,9	0,0	0,0	0,0	0,0	0,0	0,0
Agencies	0,0	0,0	6,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Supranational	0,0	0,0	3,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Supranationals deposits	0,0	0,0	5,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Multilateral Entities	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Deposit in banks and currency	84,3	0,5	1,4	0,0	18,8	0,3	3,1	0,1	36,5	0,8
Interest bearing notes	53,2	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Capital Market Inv&Sec	0,0	0,0	0,0	0,0	46,0	0,7	47,4	0,9	1,2	0,0
Discounted instruments	35,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
IMF position (Reserve Tranche, Loans)	2,7	0,0	7,5	0,0	1,7	0,0	0,6	0,0	0,4	0,0
Gold (and local sov. bonds for BRA)	5,9	0,0	3,9	0,0	1,7	0,0	0,7	0,0	2,7	0,1
Special Drawing Rights (SDRs)	3,9	0,0	0,0	0,0	0,0	0,0	0,9	0,0	2,6	0,1
Stock Indices	0,0	0,0	3,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0
US MBS	0,0	0,0	0,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Liquidity Tranche	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
External Funds	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Emerging Latin Americans	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Working Capital Tranche	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Interest Receivable Fgn Entities&Org	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Deposits received maturities <6 months	-2,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other	0,0	0,0	0,0	0,0	-0,6	0,0	0,0	0,0	1,5	0,0

Table 2. IRS allocation in currencies and asset classes for YE2019 (continuation).

IRs in US$ billion on 2019	CHI		GUA		COS		DOM		JAM	
Currencies	40,7	1,0	14,8	1,0	8,9	1,0	8,9	1,0	3,6	1,0
U.S. dollar	21,1	0,5	0,0	0,0	8,7	1,0	0,0	0,0	3,3	0,9
Euro	4,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Pound Sterling	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Japanese Yen	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Canadian Dollar	3,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Australian Dollar	3,3	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
SDR	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,1
Singapore Dollar	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
New Zeeland Dollar	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Offshore Chinese Yuan	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Swiss Franc	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other currencies	9,2	0,2	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0
Gold	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Asset Class	40,7	1,0	14,8	1,0	8,9	1,0	8,9	1,0	3,6	1,0
Sovereigns	0,0	0,0	7,3	0,5	2,8	0,3	0,0	0,0	0,0	0,0
Agencies	0,0	0,0	2,4	0,2	2,2	0,3	0,0	0,0	0,0	0,0
Supranational	0,0	0,0	0,8	0,1	0,0	0,0	0,0	0,0	0,0	0,0
Supranationals deposits	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Multilateral Entities	0,0	0,0	0,0	0,0	0,8	0,1	0,0	0,0	0,0	0,0
Deposit in banks and currency	0,0	0,0	2,1	0,1	2,8	0,3	8,6	1,0	0,0	0,0
Interest bearing notes	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Capital Market Inv&Sec	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,1
Discounted instruments	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
IMF position (Reserve Tranche, Loans)	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0
Gold (and local sov. bonds for BRA)	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Special Drawing Rights (SDRs)	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,1
Stock Indices	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
US MBS	0,0	0,0	1,5	0,1	0,0	0,0	0,0	0,0	0,0	0,0
Liquidity Tranche	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,0	0,6
External Funds	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,7	0,2
Emerging Latin Americans	0,0	0,0	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,0
Working Capital Tranche	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,1
Interest Receivable Fgn Entities&Org	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Deposits received maturities <6 months	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other	0,0	0,0	0,7	0,0	0,0	0,0	0,1	0,0	0,0	0,0

Table prepared by the authors based on IRs reports from each CB. Sources: Data from Banco Central de Chile (2019); Banco do México (2019); Banco Central de Costa Rica (2020); Banco Central de Reserva del Perú (2020); Banco Central do Brasil (2020); Banco Central República Dominicana (2021); Banco de Guatemala (2021); Bank of Jamaica (2021); International Monetary Fund (2021).

A hedge strategy for ERA-related asset price movements is applicable, considering other traditional SAA relevant data, such as IR economic objectives, investment guidelines, and investment pillars. For some CBs in the LAC sample, an alternative could be to migrate to assets less correlated with agricultural, metals and mining and oil commodities, as an example of a scenario to be mitigated in which are expected significant impacts on those sectors. As asset alternative, commodity indices could be considered.

In addition, the SAA could drive the choice of currencies in the portfolio to those currencies that are less correlated to the specific LAC economic exposure or FX rate exposure for each country in the relevant scenarios to avoid procyclicality. The ERA analysis helps to quantify the size of the impact on the economy and the dimension of this impact in the investments of IRs. Furthermore, the choice of asset classes could include those related to clean energy. The choice of currency is easier from a traditional perspective. In contrast, the choice of asset classes is more difficult due to liquidity issues, since green asset classes eligible to CBs are traditionally agencies, supranationals, and some sovereign issuers. However, it would be possible to search for small amounts of investments in these kinds of asset classes.

4.1 DISCUSSION PER COUNTRY

For Jamaica, IRs totaled US$3.63 billion in 2019, representing 22% of the national GDP and 2201% of total annual merchandise exports. Thus, exports would not be as relevant in the discussion of the ERA for the IRs, as detailed in Table 3. However, ERA analysis is strongly recommended because Jamaica has the third highest economic risk worldwide from multiple hazards (The World Bank, 2010). Jamaica is located in "Hurricane Alley," so it also faces geophysical hazards. Tropical storms, floods, and hurricanes are the disasters that have had the greatest impact in Jamaica. Between 1980 and 2008, the country experienced 27 natural disasters, with total economic damages around US$2.6 billion. In this context, to test various hypotheses, an ERA-IRs-SAA strategy could focus on hedging against variances in the local currency, with assets less correlated or negatively correlated to the Jamaican dollar (JMD) and/or with lower exposure to common physical climate risks (e.g., different geographical areas and conditions).

The Dominican Republic is in a similar situation. IRs totaled US$8.87 billion in 2019, representing 10% of the national GDP and 781% of total annual merchandise exports. Although exports are not expressive in relation to IR volume, ERA analysis is strongly recommended because the country has the second highest economic risk worldwide from multiple hazards (The World Bank, 2010).

For Mexico, based on its total manufactures exports, 85% of sales are to the United States. Manufactures are 78% machinery and transport equipment, 33% road vehicles, 13% electrical equipment, 9% office and data processing machines, 9% telecoms equipment, 6% industrial equipment, and 8% other products.

In an ERA-SAA integration analysis for IRs, environmental factors could include ecosystemic physical risk (e.g., industrial water scarcity), as well as technological (e.g., electric vehicles) and policy transition risk (e.g., regulation towards CO_2 emissions). Key economic sectors include industry (e.g., road vehicles, electrical and telecom equipment, office, and data processing machines). Scenarios could include future water availability and NGFS climate scenarios for CBs and supervisors. Environmental risks with financial impacts include increased water costs (or even unavailability) and increased CO_2 emission costs.

For Costa Rica, based on total manufactures exports, 42% of sales are to the United States, with 6% to the Netherlands, 6% to Belgium, 5% to Guatemala, 5% to Panama, and 4% to Nicaragua. Manufactures are 23% fruits and vegetables, 23% medical instruments, 8% chemicals and related products,

7% machinery (mainly electrical), and 6% orthopedic appliances.

In an ERA-SAA integration analysis for IRs, environmental factors could include ecosystemic physical risk (e.g., industrial water and energy scarcity and extreme weather events) and policy transition risk (e.g., regulation of CO_2 emissions). Key economic sectors are fruits, medical instruments, chemicals and related products, machinery (mainly electrical), and orthopedic appliances. Scenarios could include future water availability and NGFS climate scenarios for CBs and supervisors. Environmental risks with financial impacts include increased water costs (or even unavailability), increased CO_2 emission costs, and crop failures due to physical climate impact.

For Chile, based on total merchandise exports, 32% of sales are to China, with 14% to the United States, 9% to Japan, 7% to Canada, 7% to Korea, and 5% to Brazil. The merchandise is 48% copper, 11% vegetables and fruits, and 9% fish and similar products.

In an ERA-SAA integration analysis for IRs, environmental factors could include transition--related future copper demand (metals for renewable energy), ecosystemic physical risk (e.g., industrial water and energy scarcity and extreme weather events), and policy transition risk (e.g., regulation of CO_2 emissions and sustainable mining). Key economic sectors are copper, fruits, and fish. Scenarios could include future water availability and NGFS climate scenarios for CBs and supervisors. Environmental risks with financial impacts could include transition-related copper price increases due to higher demand for electronics, electric vehicles (EVs), renewable energy sources, and energy efficiency; increased water costs (or even unavailability); increased CO_2 emission costs with impacts on energy prices; interruptions in copper production due to extreme weather events (e.g., earthquakes), with impacts on copper production volumes and prices; and decreased crop and fish production due to physical climate impact, with impacts on fruit and fish production volumes and prices.

For Brazil, IRs totaled US$356.89 billion in 2019, representing 19% of the national GDP and 160% of total annual merchandise exports. Food and agriculture represented 40% of exports, and fuel accounted for another 14% (11% crude oil). According to the IMF's (2020) ARA metrics, 5% of total exports should be covered by IR assets allocated to hedge sudden stops in capital flows. In the Brazilian case, this would account for US$11.13 billion. Thus, a food and agriculture hedge of 40% of total exports would account for US$4.44 billion (1.2% of IRs), and a fuel hedge of 14% of total exports would account for US$1.53 billion (0.4% of IRs). Environmental risks have a direct impact on exports and capital flows and, from this perspective, an indirect impact on IRs, considering their economic objectives of payment execution and intervention in FX markets. In an ERA for the SAA of the IRs, the environmental factors would be mainly food, agriculture, and energy. The related environmental risks with financial percentage impacts in some specific time horizons could be increased CO_2 emission costs and crop failures due to physical climate impacts. Some expected asset price movements due to these crisis scenarios would reduce the country's exports and impact the FX rate.

In all cases, SAA could focus on hedging ERA-related asset price movements, as detailed in Table 3, as well as considering other traditional SAA-relevant data (e.g., IR economic objectives, investment guidelines and investment pillars).

Table 3. ERA-IRS-SAA: focus to be considered for hedge purposes

US$ billion in 2019	Mexico	Brazil	Peru	Colombia	Argentina	Chile	Guatemala	Costa Rica	Dominican Republic	Jamaica	Total
IR	183,06	356,89	67,71	52,65	45,22	40,66	14,78	8,94	8,87	3,63	782,40
GDP	1.258,30	1.839,80	226,80	323,80	449,70	282,30	76,70	61,80	88,90	16,50	
% IRs/GDP	15%	19%	30%	16%	10%	14%	19%	14%	10%	22%	
Total merchandise exports	461,12	222,64	47,77	39,46	65,12	69,68	11,19	11,80	1,14	0,17	930,08
% IRs/Exports	40%	160%	142%	133%	69%	58%	132%	76%	781%	2201%	
% IR assets allocated to hedge sudden stops in capital flows (ARA*)	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Total IR assets allocated to hedge of the external liabilities related to exports	23,06	11,13	2,39	1,97	3,26	3,48	0,56	0,59	0,06	0,01	46,50
Hedge for food & agriculture on total exports (e.g.: 40% BR)	1,78	4,44	0,56	0,37	2,00	1,13	0,29	0,25	0,02	0,00	10,83
Hedge for fuel on total exports (e.g.: 14% BR)	1,22	1,53	0,16	1,08	0,12	0,03	0,03	-	0,00	0,00	4,17
Hedge for ores & metals on total exports	0,42	0,14	1,09	0,02	0,02	1,83	0,00	0,01	0,00	0,00	3,53
Hedge for manufactures exports	17,73	3,72	0,23	0,42	0,57	0,49	0,24	0,33	0,04	0,00	23,76
%Hedge for food & agriculture / IRs	1,0%	1,2%	0,8%	0,7%	4,4%	2,8%	1,9%	2,8%	0,2%	0,1%	1,4%
%Hedge for fuel / IRs	0,7%	0,4%	0,2%	2,0%	0,3%	0,1%	0,2%	0,0%	0,0%	0,0%	0,5%
%Hedge for ores & metals / IRs	0,2%	0,0%	1,6%	0,0%	0,0%	4,5%	0,0%	0,1%	0,0%	0,1%	0,5%
%Hedge for manufactures / IRs	9,7%	1,0%	0,3%	0,8%	1,3%	1,2%	1,6%	3,7%	0,4%	0,0%	3,0%
ERA- IR- SAA: focus to be considered for hedge purposes											
Exports/Commodities	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	
Currency	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	

Source: prepared by the authors based on data from (The World Bank, 2021).

5   CONCLUSION

This study discussed the specific environmental risk exposures of ten CBs from LAC and respective IRs, including hedge alternatives, and it proposed specific percentages to be considered. The study is relevant to the construction of IR investment portfolios in LAC. It considers national exposure, the IRs' economic objectives, and the various angles that must be contemplated in the allocation of investment portfolios among countries and instruments.

The framework discussed herein includes ERA in the traditional SAA approach of IRs. As result, ERM is possible. The main argument is that CBs should include ERA in the traditional SAA approach because of the relevance of environmental risks to which IRs are exposed. In this LAC sample, commodities are in focus due to the IRs' economic objectives. The environmental risk exposures of the food and agriculture, fuel, and ores and metal sectors are identified, as are relevant exposures to physical climate risks in both countries located in the Caribbean (Jamaica and Dominican Republic), within the sample of ten countries.

For IR management, each viable portfolio should also be evaluated based on an ERA. A hedging strategy is applicable for price movements of assets with relevant exposure to environmental risks, based on ERA, considering other traditional SAA relevant data, such as IRs' economic objectives, investment guidelines, and investment pillars. An alternative to some CBs in the LAC sample could be to migrate to assets less correlated with commodities and currencies to mitigate relevant scenarios.

For instance, hedging alternatives might include assets that are less correlated, or even negatively correlated, to the commodities that are economically relevant to the national exports. In addition, carbon intensity indicators can be considered in the review of SAA allocation to mitigate climate transition risks.

This study only addresses the environmental aspects of the ESG factors. Further studies could focus on social and governance factors from the IR management perspective. In addition, despite our holding initial meetings with the sample of CB representatives from LAC, only one of them answered the questionnaire, which limits the applicable discussion of the framework. Our next study will focus on the risk–return analysis of the applied framework using specific asset alternatives and portfolios.

6   CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

7   AUTHOR CONTRIBUTIONS

VT is the main author, gathered the data, carried out the numerical analyses, prepared the figures and wrote the main text. AS supervised the work. SJ contributed with the articulation with LAC CBs. AS and SJ contributed to the analyses, to writing and reviewing the article. JA contributed to the supervision and methodology of the work. All authors contributed to the editing of the manuscript and the interpretation of the results.

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10   SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found attached.

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12   APPENDIX A

Framework validation questionnaire: Environmental Risk Analysis (ERA) in the Strategic Asset Allocation (SAA) of the International Reserves (IRs) managed by CBs (CBs).

For questions of group 1 (environemntal factors) and 4 (SAA), please consider the scale 1 to 7, where 1 means lower and 7 means higher. Please use 8 if you do not feel confortable to express an opinion. Please also sign de direction of the impact, if Positive (P) or Negative (N). Probability of ocurrence will reflet exposure in time (e.g.: one incident in 10 years). Impact of the ocurrence will reflect the size of the expected event.

1 Environmental factors
1,1 Environmental physical factors
1.1.1 Environmental physical climatic factors
In your personal understanding, how exposed to the following physical climatic factors is/are

	the economy of your country?			the exports and imports of your country?			the IRs of your country?		
	Probability of ocurrence	Impact of ocurrence	(P) or (N) Impact	Probability of ocurrence	Impact of ocurrence	(P) or (N) Impact	Probability of ocurrence	Impact of ocurrence	(P) or (N) Impact
1.1.1.1 CO2 levels;									
1.1.1.2 Global temperature;									
1.1.1.3 Global precipitation;									
1.1.1.4 Ice level and snow cover;									
1.1.1.5 Ocean temperature, level and ph.									

1.1.2 Environmental physical geologic factors
In your personal understanding, how exposed to the radiative forcing, which is the difference between the sunlight aborved by the Earth and the energy radiated back to space (the scientific basis for the greenhouse effect), is/are

	the economy of your country?			the exports of your country?			the IRs of your country?		
	Probability of ocurrence	Impact of ocurrence	(P) or (N) Impact	Probability of ocurrence	Impact of ocurrence	(P) or (N) Impact	Probability of ocurrence	Impact of ocurrence	(P) or (N) Impact
1.1.2.1 Radiative forcing;									

1.1.3 Environmental physical ecosystemic factors
In your personal understanding, how exposed to the following physical ecosystemic factors is/are

	the economy of your country?			the exports of your country?			the IRs of your country?		
	Probability of ocurrence	Impact of ocurrence	(P) or (N) Impact	Probability of ocurrence	Impact of ocurrence	(P) or (N) Impact	Probability of ocurrence	Impact of ocurrence	(P) or (N) Impact
1.1.3.1 Biodiversity;									
1.1.3.2 Resource usage;									
1.1.3.3 Ecosystem services.									

Link w/ Torinelli&SilvaJr Framework

1.1.1

1,2 Environmental transition factors

In your personal understanding, how exposed to the following enviromental transition factors is/are

	the economy of your country?			the exports of your country?			the IRs of your country?		
	Probability of ocurrence	Impact of ocurrence	(P) or (N) impact	Probability of ocurrence	Impact of ocurrence	(P) or (N) impact	Probability of ocurrence	Impact of ocurrence	(P) or (N) impact
1.2.1 Policy and legal;									
1.2.2 Technology;									
1.2.3 Sentiment/Reputation;									

1,3 Environmental physical and transition factors

1.3.1 In your personal understanding, how exposed to the environmental physical and transition factors is the economy of your country? What are the main sectors at risk?

_____
_____
_____

1.3.2 In your personal understanding, how exposed to the environmental physical and transition factors are the exports of your country? What are the main sectors at risk?

1.3.3 In your personal understanding, how exposed to the environmental physical and transition factors is the IR portfolio of your country? What is the main exposure: currency, country, instrument?

1.3.4 In your opinion, is the IR of your country exposed to the environmental risks or to the global actions taken in order to mitigate and to adapt to the environmental risks (e.g.: changes in the energy matrix with impact in the national economies)? Why/How?

1.3.5 In your opinion, which instruments and measures may mitigate the exposure of the IRs management to the environmental risks?

2 Assessment of environmental risk in time

1.1.2

2.1 In the context of the IR management, does the CB you represent feed, monitor or query any historical database of environmentally related events with financial impacts? If yes, could you detail it? Thank you!

Yes	No

2.2 In the context of the IR management, does the CB you represent assess environmental risk exposure in time?

Yes	No

2.2.1 If Yes was the answer to question 2.2, how do you assess the environmental risk exposure of the IRs portfolios in time? If "scenario analysis" or "stress test" are used, please detail which scenarios are considered. If "other technique" is used, please detail it.

Scenario Analysis	Stress Test

2.2.2 If Yes was the answer to question 2.2, which risk metrics do you consider in your analysis (e.g.: Weighted Average Carbon Intensity; Total Carbon Emissions; Carbon Footprint; Carbon Intensity; Exposure to Carbon Related Assets; Decline in revenues; Increase in costs; Impact on exports etc)?

3 Translation of environmental exposures into measured financial risks

3.1 Business Risk

In the management of IRs, do you translate enviromental fators into business risk? If yes, how?

3.2 Market Risk

In the management of IRs, do you translate enviromental fators into market risk? If yes, how?

3.3 Credit Risk

In the management of IRs, do you translate enviromental fators into credit risk? If yes, how?

3.4 Systemic Risk

In the management of IRs, do you translate enviromental fators into systemic risk? If yes, how?

3.5 ERA methodology - Investment Portfolio

3.5.1 Do you consider any methodology for evaluating environmental risk exposure in an investment portfolio? If so, which one? If not, why?

3.5.2 Do you use or know any methodology for contemplating environmental risk in choosing an efficient investment portfolio (eg: multi-objective optimization)? What methodology?

4 International Reserves (IRs) & Strategic Asset Allocation (SAA)

4.1 What are the economic objectives of the IRs managed by the CB you represent?

4.2 What are the investment guidelines of the IRs managed by the CB you represent?

4.3 What is the character of the IRs management in the CB you represent? E.g: priorities among the three pillars of investment (profitability, liquidity, safety); counterciclicality and market neutrality concerns etc.

4.4 What are the top 5 asset classes of the IRs portfolios in the CB you represent, and which is the percentage allocated in each of them?

4.5 What are the top 5 currencies of the IRs portfolios in the CB you represent, and which is the percentage allocated in each of them?

4.6 What are the SAA model approaches used for IR management by the CB you represent?

5 Environmental Risk Analysis (ERA) & SAA

5.1 Economic objectives

In your perspective, how exposed to environmental risks are the following typical IR economic objectives?

	Probability of ocurrence	Impact of ocurrence	(P) or (N) impact
5.1.1 Intervention in the FX markets;			
5.1.2 Execution of payments for goods and services;			
5.1.3 Execution of payments for the government;			
5.1.4 Granting of emergency liquidity assistance;			
5.1.5 Support of domestic monetary policy;			
5.1.6 Underpinning of investor confidence in the country;			
5.1.7 Investment of excess reserves.			

1.1.3

1,2

2 & 3

5.2 Assets

In your perspective, how exposed to environmental risks are your IRs portfolios due to the following asset classes?

	Probability of ocurrence	Impact of ocurrence	(P) or (N) impact
5.2.1 Treasury Bonds;			
5.2.2 Supranationals;			
5.2.3 Sovereign Eurobonds;			
5.2.4 US Agencies;			
5.2.5 Inflation Protected Bonds;			
5.2.6 Corporate and covered bonds;			
5.2.7 MBS/ABS			
5.2.8 Equities;			
5.2.9 Banks Debt;			
5.2.10 Green Bonds;			
5.2.11 Other- which?_____			

5.3 Currencies

In your perspective, how exposed to environmental risks are your IRs portfolios due to the following currencies?

	Probability of ocurrence	Impact of ocurrence	(P) or (N) impact
5.3.1 USD;			
5.3.2 EUR;			
5.3.3 CNY			
5.3.4 JPY;			
5.3.5 GBP;			
5.3.6 Other- which?_____			

5.4 How do you understand that the Environmental Risk Management may impact the IR Economic Objectives and the IR Investment Guidelines?

5.5 How do you understand that the Environmental Risk Management may impact the IR Strategic Asset Allocation?

5.6 In your opinion, what would be the effect on the short term and long term financial returns of the IRs due to a partial reallocation of its portfolio to green investment alternatives that suit the investor profile of CBs and mitigate their exposure to environmental risks (and/or their exposure to global actions taken in order to mitigate and to adapt to the environmental risks)? For example: would it be most probably negative in the short term and positive in the long term? Why?

5.7 In your opinion, how an incremental performance of the International Reserves, managed by the Central Banks, in the Green Finance market would impact this market segment, as well as the Green Economy? Do you believe it would significantly modify the depth and liquidity of the Green Finance market, impacting the Green Economy*? Why/How?

6 ESG Investment Strategy

2 & 3

6.1 Does the CB you represent has any ESG investment strategy? If yes, how would you define it? Reference: http://www.eurosif.org/responsible-investment-strategies/

Best-in-class	☐	Engagement & Voting	☐	
Impact Investing	☐	ESG Integration	☐	
Norms-based screening	☐	Exclusions	☐	
Sustainability-themed	☐	Other - Please specify: _____	☐	
No ESG investment strategy.	☐			

6.2 What are (or would be) your drivers for considering alternatives of ESG investments?

Management based on ERA	☐	Support the Green Market Growth	☐	
Diversification	☐	Climate risk mitigation	☐	
Institutional reputation	☐	Other - Please specify: _____	☐	
Superior returns	☐	No driver for ESG investments.	☐	

6.3 Which of the following green asset classes does the CB you represent consider for investments with the IR:

Green Bonds	☐	Green Index	☐	
Green Investment Funds	☐	Green Exchange Traded Funds-ETFs	☐	
Green Investment Trusts	☐	Unlabeled Green Assets	☐	
Green Equities	☐	Other - Please specify: _____	☐	

6.4 Which currencies you think may better support a strategy of mitigating climate risks in IR management?

USD	☐	GBP	☐
EUR	☐	JPY	☐
Other - Please specify: _____	☐		

6.5 Does the CB you represent has investments allocated in any Green Asset? If Yes, please select in which assets you actually invest (if No, please jump to question 6.11):

Green Bonds	☐	Green Index	☐
Green Investment Funds	☐	Green Exchange Traded Funds-ETFs	☐
Green Investment Trusts	☐	Unlabeled Green Assets	☐
None Green investments	☐	Other - Please specify: _____	☐

6.6 If Yes was the answer to question 6.7, please indicate which is your average percentage of investments in green assets, considering the total amount of investments of the CB (0% up to 100%):_____

6.7 Please indicate which categories of green bond issuers is the CB you represent interested in?

Sovereign	☐	Supranational	☐
Corporate	☐	Agencies	☐
Financial Institutions	☐	Municipals	☐

6.8 Does the CB you represent has any plan to adopt the analysis of ESG (Environmental, Social and Governance) factors in its balance sheet management, besides the management of the IRs (or is already doing so)?

Yes - Please specify how: _____	☐
No	☐
I cannot inform	☐
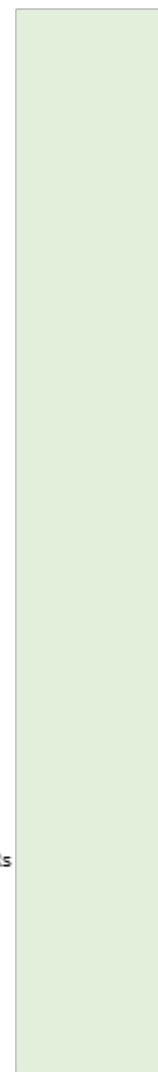
6.9 Please indicate the most probable proportion that the Green Assets will represent in the total investment portfolio of the CB you represent, in ten years from now (2030) (0% up to 100%):

For the purpose of the management of the investment portfolio, for questions 6.13 to 6.24 please consider the scale 1 to 7, where 1 means less probable and 7 means more probable:

6.10' Does the CB you represent would avoid investing in Green Assets due to low liquidity (high Bid-Ask Spread, low Turnover)?

1-No	2	3	4	5	6	7-Yes

6.11 Does the CB you represent would take into consideration to invest in Green Assets with an objective to explore the higher Yeld due to lower liquidity (with higher liquidy risk, in case of assets been sold previously to the due date)?

1-No	2	3	4	5	6	7-Yes

6.12 Does the CB you represent see Green Assets as a market with low depth (Outstanding)?

1-No	2	3	4	5	6	7-Yes

6.13 Does the CB you represent would take into consideration to invest in Green Assets despite of a low depth (Outstanding)?

1-No	2	3	4	5	6	7-Yes

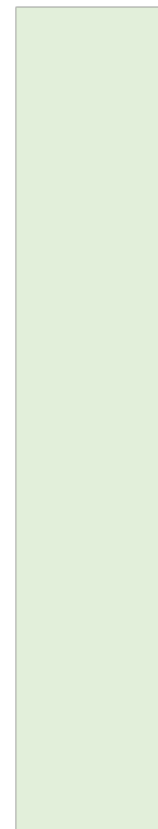**6.14** Does the CB you represent would take into consideration to invest in Green Assets as protection strategy (e.g.: not losing money)?

1-No	2	3	4	5	6	7-Yes

6.15 Does the CB you represent would avoid investing in Green Assets due to safety issues, as increased default risk?

1-No	2	3	4	5	6	7-Yes

6.16 Does the CB you represent would avoid investing in Green Assets due to reputational risk?

1-No	2	3	4	5	6	7-Yes

6.17 Does the CB you represent would take into consideration to invest in Green Assets as a strategy to support the Green Finance and the Green Economy?

1-No	2	3	4	5	6	7-Yes

6.18 Does the CB you represent would take into consideration to invest in Green Assets as a strategy to mitigate the potential economic risks due to global actions taken in order to mitigate and to adapt to environmental risks (e.g.: changes in the energy matrix with impact in the national economies)?

1-No	2	3	4	5	6	7-Yes

6.19 Does the CB you represent is concerned about green washing associated with the green assets available in the market?

1-No	2	3	4	5	6	7-Yes

6.20' Does the CB you represent is concerned about lack of standardization of the the green assets available in the market?

1-No	2	3	4	5	6	7-Yes