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Central Bank Digital Currencies in 3D: *systematizing pros, cons and design choices*

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Central Bank Digital Currencies in 3D:
systematizing pros, cons and design choices [*]

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Abstract

While numerous countries have been advancing their CBDC projects for many years, nearly all of them are still far from making a final decision about issuing a CBDC or not. Our explanation is CBDC involving far too many tradeoffs: prioritizing some objectives (1st "dimension") necessitates specific design choices (2nd "dimension") that make another long list of objectives impossible to achieve (3rd "dimension"). Modeling these tradeoffs in a systematic manner has been lacking from the CBDC literature. We contribute on this front by building a CBDC Design Toolkit, available to interested readers on request. After applying this toolkit to two country cases, we uncover more than a dozen of tradeoffs that each of the country authorities has not covered in their CBDC-related official publications. This demonstrates in a structured way why so many CBDC projects have stalled after early enthusiasm. It also partially explains why there are so many different views on CBDC and why emerging economies have been more active on this front.

JEL Codes: E41, E42, E44, E5

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1. Introduction

Many countries have been studying the introduction of a central bank digital currency (CBDC) for years already. Right before Sweden published its first report on e-krona, the central bank officials believed that "the Riksbank has never before launched such a complicated project in such an unknown area" (Skingsley, 2016). Eight years later and they are still studying the topic without a decision to issue a CBDC or not to issue one. Many other countries are in a similar situation, conservatively analyzing the big picture, and for good reason – CBDCs can have a profound impact on the economy and financial system, not only positive but negative as well (see Mkhatrishvili and Boonstra, 2022 for an in-depth review of CBDC benefits, costs and design choices as well as under-researched areas). Understanding these effects and, most importantly, how they may be intertwined is very difficult because of its multidimensionality. Namely, authorities have realized that in order to achieve a given policy objective with a CBDC, they need to make some specific design choices, which would then exclude the option of achieving another set of objectives. Yet CBDC design has so many facets (anonymity, decentralization, accessibility, remuneration, caps, etc.), combination of each generating their own kind of tradeoffs. That is exactly what makes the project so complex. According to Dowd (2024), so far CBDC projects have failed or have suffered a low degree of public demand. In his words: "*Experience suggests that CBDCs do not offer tangible benefits which existing alternatives cannot already deliver*" (Dowd, 2024). Another reason might be that central banks do not fully understand how certain design choices may make certain CBDC policy objectives incompatible with each other.

If we were to properly design a CBDC it would be beneficial for our economies, at least that's what 84% of expert panel members think in the survey of Crumpton and Ilzetzki (2021) for the case of the UK[4]. Also, consumers' payment behavior is quite persistent – they switch between payment methods only gradually[5] and, if they settle at one, stick to it persistently (Brown et al, 2020). In this sense, getting design principles right from the very beginning is important for both incentivizing consumers with slow-moving preferences to shift towards a CBDC as well as having a CBDC that will not need a major overhaul once it is already live. If an already introduced CBDC turns out to be unsuccessful, then by implication even any other form of money of the same central bank may be questioned. We know that gaining central bank credibility is very difficult while losing it can happen quickly. Hence, taking this credibility issue into account is very important. However, this paragraph starts with a big if – proper design of a CBDC is something that, as mentioned above, is taking years and we are still not there yet.

[4] However, Cecchetti and Schounholtz (2021) disagree, who think that CBDC is not necessary to solve the existing financial system problems. They point to the introduction of fast retail payments by central banks and India as an example of increasing financial inclusion without the need for CBDC.

[5] There are exceptions, naturally, when a newly introduced system is highly successful. For example, in the Netherlands the introduction of the so-called contactless payment technology in 2015 brought a revolutionary change. Five years later it was by far the most popular way of conducting payments. The share of 'old fashioned' PIN-transactions in the number of transactions has more or less collapsed.

True, Group of Central Banks (2020) have identified the foundational principles that CBDCs would be required to satisfy. These "principles emphasise that: (i) a central bank should not compromise monetary or financial stability by issuing a CBDC; (ii) a CBDC would need to coexist with and complement existing forms of money; and (iii) a CBDC should promote innovation and efficiency". But this is not nearly specific enough for a particular central bank to actually go live with a CBDC. Decisions on every aspect of design is still necessary. Some have provided more specific (but only partial) proposals. For example, while acknowledging that CBDCs are not automatically an equivalent of electronic cash, OMFIF-IBM (2019) argues that it should be designed in such a way that it eventually does exhibit the properties of cash. If this means (almost) full anonymity, then what are the implications for tax evasion, money laundering or terrorism financing? On the other hand, De Nederlandsche Bank (2020) argues that it would make sense to introduce some frictions to accessing CBDCs by the general public as this would be "in line with the policy for existing forms of central bank money, reserves and cash, for which explicit and implicit frictions apply". The argument for this is that it would limit the potential disintermediation problem by making CBDCs less of a competitor with deposits. The frictions may take the form of quantitative limits/ceilings (e.g. Gürtler et al, 2017), issuance only against government bonds (Kumhof and Noone, 2018) or fees (Bindseil, 2020). But how can such CBDCs then compete with stablecoins or foreign currencies?[6]

The list of this kind of questions (tradeoffs) is very long and, again, that is why CBDC projects are taking years if not decades. This article tries to help in speeding things up by providing a model/toolkit that systematizes these tradeoffs in a unifying framework. Namely, within a formal yet simple model, we link (a full set[7] of) CBDC objectives with (a full set of) design choices. Even though the idea of linking these different facets of a CBDC is quite simple, solving a system this big (even if static) with pen and paper is close to impossible (multi-dimensional, multiple solutions), let alone mentally imagining all these interlinkages. Using a certain toolkit/model is unavoidable if one wants to look at those interlinkages/tradeoffs systematically (big picture) in a structured way. This is the area we try

[6] We think that competing with stablecoins or foreign monies is more relevant for small and open economies with a relatively low degree of monetary stability/ central bank credibility than for large economies with a major currency (like EMU, US, UK, etc.). But even the ECB or the Fed still sometimes mention "monetary sovereignty" argument when talking about potential benefits of a CBDC.

[7] By "full set" we mean a complete list of potential CBDC objectives as listed in our previous paper (Mkhatrishvili and Boonstra, 2022), where we tried to capture all of them that was mentioned in the CBDC literature at the time. Of course, there could be some papers that we missed in our review.

to contribute by building our **CBDC Design Toolkit**, which will be available to interested readers upon request from the authors. To the best of our knowledge, no such toolkit[8] was available before[9].

To showcase usefulness of the toolkit we apply it to a couple of country CBDC projects. For example, as the analysis of the US CBDC-project within our toolkit showed, the Fed's discussion paper on CBDC (Board of Governors of the Federal Reserve System, 2022) seems to have missed 5 tradeoffs (i.e. listed CBDC objectives that were likely incompatible with each other), while simply not mentioning 13 other tradeoffs they'll be facing, based on today's technological frontiers (assumptions about these are captured by calibrating parameters[10] of our toolkit). Spotting so many (in case of the US, 18) tradeoffs of a CBDC without a toolkit is very difficult. That's what our CBDC Design Toolkit is for. A similar message comes from applying the toolkit to the Georgian case (National Bank of Georgia, 2023), a small open emerging economy that likely has different priorities relative to the big developed market like the US: even though objectives and, hence, design choices may be somewhat different, the intensity of tradeoffs is still almost the same.

The article is organized in the following way: in the next section we formally describe the model incorporated in our toolkit. In Section 3 we use the toolkit to systematically analyze CBDC tradeoffs and needed design choices in a couple of country cases, while the last section concludes. The toolkit itself (which, at this point, is Excel-based) is available upon request.

2. CBDC in 3D

Here we build a relatively simple static model which links CBDC's pros, cons and design choices. As extensively discussed by Mkhatrishvili and Boonstra (2022), trying to achieve a certain set of objectives (which can be both realizing a benefit of a CBDC as well as minimizing a cost/risk of it) will (a) requires a particular combination of design choices and (b) as a result exclude the possibility of achieving another set of objectives. This is what we formalize here. Let's assume the following relationship:

[8] An overview of all the input that went into this toolkit, with a higher degree of detail than we can give in this article, was already published in our previous paper (see Mkhatrishvili and Boonstra, 2022).

[9] World Economic Forum has published a CBDC toolkit, but it is not a model that systematically links CBDC costs, benefits and design choices. It is mostly a guide that verbally discusses how CBDC implementation *process* can be planned at a central bank. See WEF (2020).

[10] This, which is the only input from a toolkit user, can easily be changed, if one thinks that our calibration is incorrect.

$$b_1 = \mathcal{B}_1(d) \quad (1)$$

…

$$b_n = \mathcal{B}_n(d)$$

where $\mathcal{B}(\cdot)$ functions are mappings from design choices (d) to objectives[11] of a CBDC (b). As is clear, here we have n number of CBDC objectives so that b is an n-dimentional vector. Design choices d, in turn, is a k-dimentional vector – i.e. we have k different design choices (e.g. anonymity, remuneration, etc.) each of which, for simplicity, can take only three values in our model: $'No'$, $'Partial'$ or $'Yes'$. With a certain combination of these k design choices, each objective variable (b) will take a value of either $'True'$ or $'False'$ (the objective can either be achieved with this particular combination of design choices or not).

In reverse, given one of the objectives from b is equal to $'True'$, the above equations can have multiple solutions though. For example, let's assume that objective b_1 is neutral in terms of anonymity feature (let's call the anonymity design choice d_1), meaning that b_1 objective can be achieved no matter what the value of d_1 is (whether it is equal to $'No'$, $'Partial'$ or $'Yes'$). Then this means one of the equations from the system (1) above (namely the equation $b_1 = \mathcal{B}_1(d) = 'True'$) has three solutions. Similarly, maybe b_2 objective can be realized if anonymity feature is at least partial. Hence, there can be two solutions for $b_2 = \mathcal{B}_2(d) = 'True'$ equation: one with $d_1 = 'Partial'$ and another with $d_1 = 'Yes'$. Finally, b_3 can be such an objective that can *only* be achieved if anonymity is (close to) full – i.e. only one solution for $b_3 = \mathcal{B}_3(d) = 'True'$ equation and it being with $d_1 = 'Yes'$.

In other words, if you pick some design choices d, you will get a list of objectives which you can achieve with this particular combination of design choices (i.e. objectives with $b = 'True'$), but you will also get a list of objectives which are unavoidably inconsistent with these design choices (i.e. objectives with $b = 'False'$). This is what we mean by 3-dimensional (3D) linkages[12]: (i) if you pick a set of objectives to achieve, (ii) you get a set of particular design choices needed *and* (iii) a set of objectives you cannot achieve. To emphasize these 3D interlinkages it will be useful to also formally show the mappings in reverse – from b to d[13]:

[11] As mentioned above, each objective can take two forms: (1) realizing a **b**enefit of a CBDC or (2) minimizing a cost/risk of a CBDC. We call each of both an objective.

[12] Mathematically, of course, the system is of larger dimension as it links n-dimensional and k-dimensional vectors, with n and k in our case being much higher than 3.

[13] $\mathcal{B}^{-1}(b) = \mathcal{B}^{-1}\left(\mathcal{B}(d)\right) = d$

$$d = \mathcal{B}_1^{-1}(b_1) \quad (2)$$

...

$$d = \mathcal{B}_n^{-1}(b_n)$$

This now formally emphasizes that if one picks a certain list of objectives, it will, based on (2), need to adopt a certain combination of design choices d, which in turn, based on (1), will necessarily rule out another list of objectives. Again, choosing a list of objectives-to-achieve unavoidably implies needed design choices *and* excludes another list of objectives.

Understanding a system with this amount of interlinkages unavoidably requires a certain toolkit, if one wants to look at those interlinkages/tradeoffs systematically (big picture). Yet, to our knowledge, no such systematic modeling of CBDC tradeoffs has been done so far. This is the area we try to contribute by building CBDC Design Toolkit.

At this moment, our CBDC Design Toolkit is Excel-based, but the plan is to make it web-based in the future. The only (user-provided) input to the toolkit is the mappings $\mathcal{B}^{-1}$, which essentially is a table that lists the needed design choices for each objective of a CBDC[14]. The rest of the linkages/tradeoffs will be automatically calculated, which results in the following process of CBDC evaluation:

(1) We *sequentially* choose objectives (from the list) we want to achieve (first, we choose the most important objective, then the second most important one and so on). The size of the list of objectives we can choose from shrinks at each stage, because the first objective we choose could be inconsistent with certain other objectives and the latter will be dropped from the list when we will try to choose the second objective, and so on.

(2) The list of objectives we come up with will require a certain combination of design choices and the toolkit will explicitly show those. In case there are multiple solutions, the toolkit will list all the design choices that are consistent with our list of objectives.

(3) Finally, those design choices on the second step will be inconsistent with another set of objectives and the toolkit will show that list as well, so that the user/policy-maker is conscious of the costs/risks it is taking by designing a CBDC in that particular way.

For illustration purposes (without an emphasize on the actual calibration[15]), here we provide a snapshot of a couple of important steps of the way our toolkit solves the above model. First, the user

[14] Providing this separately for each objective of CBDC is easy for a user. It's linking everything together that is the toolkit's job.

[15] The table below is above all an advanced example how this modeling toolkit works. The actual input/calibration will be provided by each user and this input may change over time due to new insights about how technology works, for example.

provides an input in the form of the following table (see Figure 1), which links design choices to each CBDC objective *separately (for each row)*. As mentioned before, this is the only user-provided input.

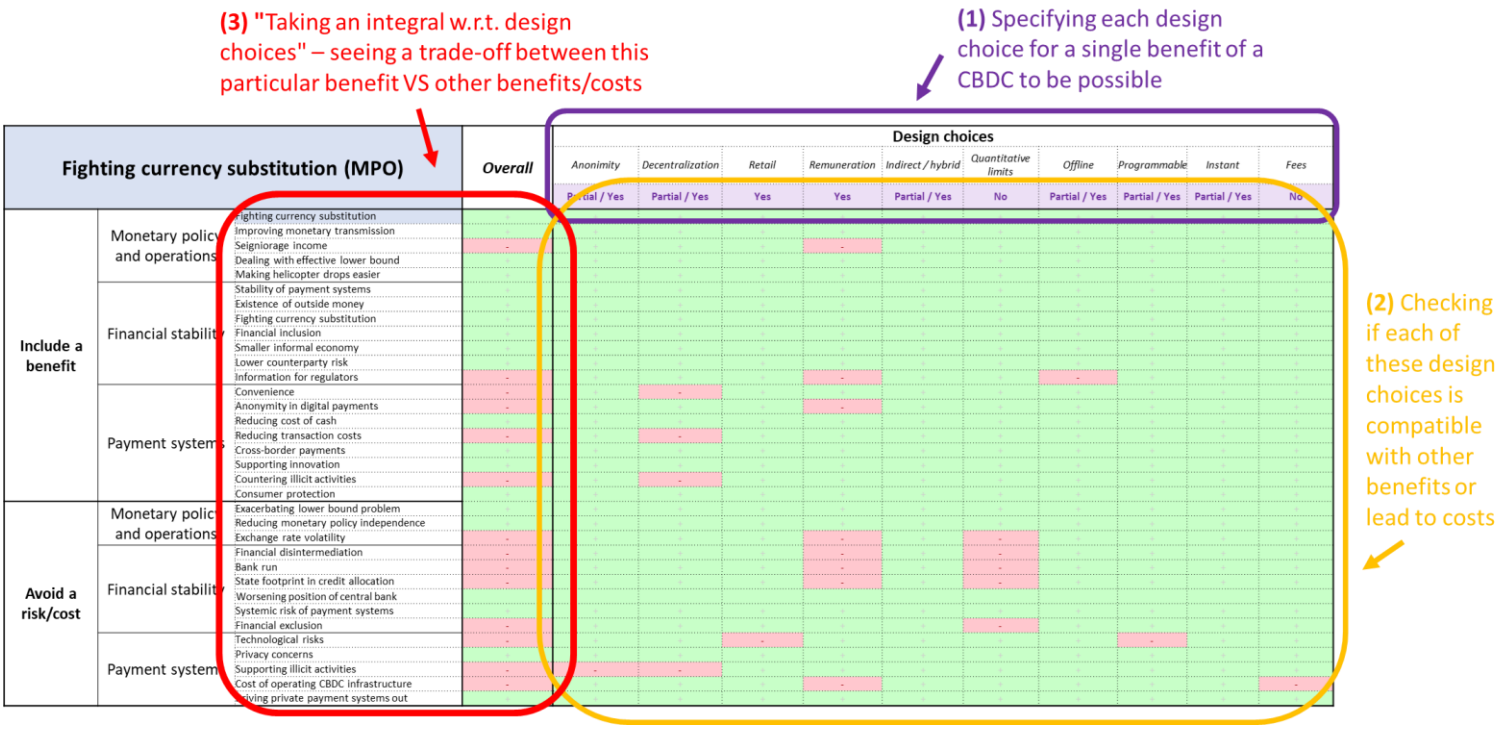
Figure 1 – User input on what design choices (columns) are needed for each CBDC objective (rows) separately

	Abbreviations				Anonymity	Decentralization	Retail	Remuneration	Indirect / hybrid	Quantitative limits	Offline	Programmable	Instant	Fees
Benefit	MP	Monetary policy and operations	FCS	Fighting currency substitution	Partial / Yes	Partial / Yes	Yes	Partial / Yes	Partial / Yes	No	Partial / Yes	Partial / Yes	Partial / Yes	No
			IMT	Improving monetary transmission	Partial / Yes	Partial / Yes	Yes	Partial / Yes	Partial / Yes	No	Partial / Yes	Partial / Yes	Partial / Yes	No
			SIN	Seigniorage income	Partial / Yes	Partial / Yes	Yes	No	Partial / Yes	No	Partial / Yes	Partial / Yes	Partial / Yes	No
			DLB	Dealing with effective lower bound	Partial / Yes	Partial / Yes	Yes	Partial / Yes	Partial / Yes	No	Partial / Yes	Partial / Yes	Partial / Yes	No
			MHD	Making helicopter drops easier	Partial / No	Neutral	Yes	Neutral	Partial / No	No	Partial / Yes	Neutral	Neutral	Neutral
	FIN	Financial stability	SPS	Stability of payment systems	Neutral	Partial / Yes	Neutral	Neutral	Yes	Partial / No	Neutral	Partial / Yes	Partial / Yes	Neutral
			EOM	Existence of outside money	Partial / Yes	Partial / Yes	Yes	Neutral	Partial / Yes	No	Partial / Yes	Partial / Yes	Partial / Yes	No
			FCS	Fighting currency substitution	Partial / Yes	Partial / Yes	Yes	Partial / Yes	Partial / Yes	No	Partial / Yes	Partial / Yes	Partial / Yes	No
			FIN	Financial inclusion	Partial / No	Partial / Yes	Yes	Partial / Yes	Partial / No	Partial / No	Partial / Yes	Partial / Yes	Partial / Yes	No
			SIE	Smaller informal economy	Partial / No	Partial / Yes	Yes	Partial / Yes	Partial / Yes	No	Partial / Yes	Partial / Yes	Partial / Yes	No
			LCR	Lower counterparty risk	Neutral	Yes	Neutral	Neutral	Neutral	No	Neutral	Yes	Yes	Neutral
			IFR	Information for regulators	Partial / No	Partial / Yes	Yes	Partial / No	Partial / No	Partial / No	No	Partial / Yes	Yes	No
	PAY	Payment systems	CON	Convenience	Partial / Yes	No	Yes	Neutral	Partial / Yes	Partial / No	Partial / Yes	Partial / Yes	Yes	No
			ANO	Anonymity in digital payments	Yes	Yes	Yes	No	Yes	No	Neutral	Neutral	Neutral	Neutral
			RCC	Reducing cost of cash	Partial / Yes	Partial / Yes	Yes	Neutral	Partial / Yes	No	Partial / Yes	Partial / Yes	Partial / Yes	No
			TRC	Reducing transaction costs	Partial / Yes	No	Yes	Partial / Yes	Partial / Yes	Neutral	Partial / Yes	Partial / Yes	Partial / Yes	No
			CBP	Cross-border payments	Partial / No	Partial / Yes	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
			INN	Supporting innovation	Neutral	Partial / Yes	Yes	Neutral	Yes	Neutral	Neutral	Yes	Neutral	Neutral
			AML	Countering illicit activities	Partial / No	No	Yes	Partial / Yes	Partial / No	No	Partial / No	Neutral	Partial / Yes	No
			CPR	Consumer protection	Partial / No	Partial / No	Yes	Neutral	Partial / No	Neutral	Partial / Yes	Neutral	Neutral	Neutral
Minimize	MP	Monetary policy and operations	ELB	Exacerbating lower bound problem	Neutral	Neutral	Neutral	Partial / Yes	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
			MPI	Reducing monetary policy independence	Neutral	Neutral	Neutral	Neutral	Yes	Neutral	Neutral	Neutral	Neutral	Neutral
			ERV	Exchange rate volatility	Neutral	Neutral	Neutral	Partial / No	Neutral	Partial / Yes	Neutral	Neutral	Neutral	Neutral
	FIN	Financial stability	FDI	Financial disintermediation	Neutral	Neutral	Neutral	Partial / No	Partial / Yes	Neutral	Neutral	Neutral	Neutral	Neutral
			BRN	Bank run	Neutral	Neutral	Neutral	Partial / No	Partial / Yes	Yes	Neutral	Neutral	Neutral	Neutral
			SFC	State footprint in credit allocation	Neutral	Neutral	Neutral	Partial / No	Partial / Yes	Yes	Neutral	Neutral	Neutral	Neutral
			PCB	Worsening position of central bank	Neutral	Neutral	Neutral	Neutral	Yes	Neutral	Neutral	Neutral	Neutral	Neutral
			SRP	Systemic risk of payment systems	Neutral	Partial / Yes	Neutral	Neutral	Yes	Neutral	Neutral	Neutral	Neutral	Neutral
			FEX	Financial exclusion	Partial / No	Partial / Yes	Neutral	Neutral	Partial / No	Partial / Yes	Partial / No	Neutral	Neutral	Neutral
	PAY	Payment systems	TEC	Technological risks	Neutral	Yes	No	Neutral	Neutral	Neutral	Neutral	No	Neutral	Neutral
			PRI	Privacy concerns	Partial / Yes	Partial / Yes	Neutral	Neutral	Yes	Neutral	Neutral	Neutral	Neutral	Neutral
			ILL	Supporting illicit activities	Partial / No	Partial / No	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
			COI	Cost of operating CBDC infrastructure	Neutral	Partial / Yes	Neutral	No	Yes	Neutral	Neutral	Neutral	Neutral	Yes
			DPO	Driving private payment systems out	Neutral	Partial / Yes	Neutral	Neutral	Yes	Neutral	Neutral	Neutral	Neutral	Neutral

Source: authors' construction

This gives us each of the reverse-mappings $\mathcal{B}^{-1}$ of the system (2). The next step, based on this, is to calculate each of the mappings $\mathcal{B}$ that will show us inconsistencies between a certain objective and the rest of objectives. Namely, Figure 2 shows the step in detail, which entails (i) importing design choices needed for a certain objective from Figure 1; (ii) checking if each of these design choices is compatible with other objectives, again based on table from Figure 1 and (iii) integrating out the dimension of design choices, which lets us check whether each objective's design choices *collectively* are compatible with other objectives.

Figure 2 – Design toolkit checking compatibility between one specific objective and the rest of objectives[16]



Source: authors' construction

Up until now, the exercise gives us a column (outlined in red circle on Figure 2) for each objective (showing whether this objective is compatible with other objectives in the list or not). After doing this exercise for each objective separately, we end up with as many columns as we have potential objectives. Combining these columns together gives us a matrix showing all the *separate tradeoffs* between all of the CBDC objectives (see Figure 3). This 2-dimensional (2D) tradeoff matrix nicely demonstrates that we cannot achieve many of the objectives together, as visualized by the frequency of red cells[17].

[16] Green means this particular objective is compatible with the other objective in question, while red means it is not.

[17] Again, red cells in the matrix represent an intersection of two objectives that are impossible to achieve simultaneously.

Figure 3 – Visualizing tradeoffs in 2D – the first result of the design toolkit

CBDC trade-off matrix				Include a benefit																		Avoid a risk/cost									
				Monetary policy and operations					Financial stability							Payment systems							MP and operations			Financial stability				Payment systems			
				FCS	IMT	SIN	DLB	MHD	SPS	EOM	FCS	FIN	SIE	LCR	IFR	CON	ANO	RCC	TRC	CBP	INN	AML	CPR	ELB	MPI	ERV	FDI	BRN	SFC	SRP	FEX	TEC	PRI	ILL	COI	DPO
Include a benefit	Monetary policy and operations	Fighting currency substitution	FCS			-									-	-	-		-			-			-		-	-			-	-		-	-	
		Improving monetary transmission	IMT			-									-	-	-		-			-			-		-	-			-	-		-	-	
		Seigniorage income	SIN	-	-		-				-	-	-		-				-			-	-		-		-	-			-	-		-	-	
		Dealing with effective lower bound	DLB			-									-	-	-		-			-			-		-	-			-	-		-	-	
		Making helicopter drops easier	MHD						-						-		-			-	-				-			-			-	-	-		-	-
	Financial stability	Stability of payment systems	SPS					-				-			-	-			-			-						-			-	-		-	-	
		Existence of outside money	EOM												-	-			-			-			-		-	-			-	-		-	-	
		Fighting currency substitution	FCS			-									-	-	-		-			-			-		-	-			-	-		-	-	
		Financial inclusion	FIN			-			-						-	-	-		-	-	-	-		-			-	-	-	-	-	-	-	-	-	-
		Smaller informal economy	SIE			-									-	-	-		-	-		-			-		-	-			-	-		-	-	
		Lower counterparty risk	LCR												-				-			-	-					-			-	-		-		
		Information for regulators	IFR	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-		-			-	-	-	-	-	-	-	-	-	-
	Payment systems	Convenience	CON	-	-	-	-		-	-	-	-	-		-		-	-		-	-						-	-		-	-	-	-	-	-
		Anonymity in digital payments	ANO	-	-		-	-			-	-	-		-	-			-			-	-	-		-	-	-			-	-		-		
		Reducing cost of cash	RCC												-	-			-			-				-	-	-			-	-		-		
		Reducing transaction costs	TRC	-	-	-	-		-	-	-	-	-		-		-	-		-	-									-	-	-	-	-	-	-
		Cross-border payments	CBP					-				-	-		-	-			-			-	-								-			-		
		Supporting innovation	INN					-				-			-	-			-			-									-	-	-			
		Countering illicit activities	AML	-	-	-	-		-	-	-	-	-	-	-		-	-		-	-			-	-		-	-		-	-		-	-	-
		Consumer protection	CPR											-			-			-						-			-	-		-	-		
Avoid a risk/cost	Monetary policy and operations	Exacerbating lower bound problem	ELB				-									-																		-	
		Reducing monetary policy independence	MPI					-				-			-							-									-					
		Exchange rate volatility	ERV	-	-	-	-	-		-	-		-	-			-	-				-														
	Financial stability	Financial disintermediation	FDI																				-													
		Bank run	BRN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				-														
		State footprint in credit allocation	SFC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				-														
		Worsening position of central bank	PCB																																	
		Systemic risk of payment systems	SRP					-				-			-	-			-				-								-					
		Financial exclusion	FEX	-	-	-	-	-	-	-	-		-	-	-		-	-		-		-		-						-	-		-		
	Payment systems	Technological risks	TEC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-		-	-									-				
		Privacy concerns	PRI					-				-	-		-	-				-		-	-								-					
		Supporting illicit activities	ILL	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-									-	-	-	-		-	-
		Cost of operating CBDC infrastructure	COI	-	-	-	-	-		-	-	-	-		-		-		-			-	-								-			-		
		Driving private payment systems out	DPO					-				-			-	-			-			-									-			-		

Source: authors' construction

However, this matrix only shows tradeoffs between two specific objectives *in isolation*. Hence, we go one step further and, based on this matrix, add the design choices' dimension back again. With this, the toolkit allows to sequentially start picking a priority objective and show the full picture. For instance, after the first objective is chosen, the toolkit shows needed design choices. It also tells which other objectives are in conflict with our choice and eliminates them from the list out of which we will be choosing our second objective. Then, after the second objective is chosen the toolkit shows design choices that are needed to collectively achieve the first and second objectives together. It then also tells which other objectives are in conflict with either our first or our second objective (or both) and eliminates them from the list out of which we will be choosing our third objective. This process continues until we run out of achievable objectives. For example, based on our calibration on Figure 1, it turns out that, for most combinations, we could pick at most 10-15 objectives out of the list of 34 potential objectives, thanks to the incompatibility driven by different design needs.

This is the second and the key result of our toolkit. Namely, after the user picks a vector of objectives we want to (and can) achieve, the toolkit also shows a vector of design choices we need (to collectively achieve all those objectives) and a vector of other objectives we have to say no to (see Figure 4 for an example).

Figure 4 – Example of the toolkit's end result (three vectors of achievable objectives, design needs and unachievable objectives)

Objectives to be achieved	
Objective #1	Benefit MP - Dealing with effective lower bound
Objective #2	Benefit FIN - Stability of payment systems
Objective #3	Benefit FIN - Fighting currency substitution
Objective #4	Benefit MP - Improving monetary transmission
Objective #5	Benefit PAY - Cross-border payments
Objective #6	Benefit FIN - Existence of outside money
Objective #7	Minimize MP - Reducing monetary policy independence
Objective #8	Benefit FIN - Lower counterparty risk
Objective #9	Benefit PAY - Reducing cost of cash
Objective #10	Minimize FIN - Systemic risk of payment systems
Objective #11	Benefit MP - Fighting currency substitution
Objective #12	Minimize FIN - Financial disintermediation
Objective #13	Benefit PAY - Supporting innovation
Objective #14	Minimize PAY - Privacy concerns
Objective #15	Minimize MP - Exacerbating lower bound problem

Needed design choices	
Anonymity	Yes
Decentralization	Yes
Retail	Yes
Remuneration	Partial
Indirect / hybrid	Yes
Quantitative limits	No
Offline	Partial / Yes
Programmable	Yes
Instant	Yes
Fees	No

Objectives given up
Benefit MP - Seigniorage income
Benefit MP - Making helicopter drops easier
Benefit FIN - Financial inclusion
Benefit FIN - Smaller informal economy
Benefit FIN - Information for regulators
Benefit PAY - Convenience
Benefit PAY - Anonymity in digital payments
Benefit PAY - Reducing transaction costs
Benefit PAY - Countering illicit activities
Benefit PAY - Consumer protection
Minimize MP - Exchange rate volatility
Minimize FIN - Bank run
Minimize FIN - State footprint in credit allocation
Minimize FIN - Financial exclusion
Minimize PAY - Technological risks
Minimize PAY - Supporting illicit activities
Minimize PAY - Cost of operating CBDC infrastructure

Source: authors' construction

Finally, it is also worth mentioning that the toolkit is created in such a way that adding other type of design choices or other potential objectives that we missed can be done reasonably easily by the model builder. Again, the toolkit is available to interested readers on request from the authors.

3. Applying the toolkit to country cases

To showcase its usage, here we apply our CBDC Design Toolkit to a couple of different country cases. Namely, we try to read between the lines[18] of central banks' reports/papers to guess what their priority objectives are. This will tell us what kind of design choices they will have to make and what tradeoffs they will face.

3.1. The US *(big advanced economy)*

A discussion paper, published by the Federal Reserve (Board of Governors of the Federal Reserve System, 2022) that we focus on in this subsection, lists a number of questions that it wants the public to comment on. One of those questions was if there are "tradeoffs around any of the identified design principles, especially in trying to achieve the potential benefits of a CBDC". Our toolkit is supposed to answer exactly this kind of questions in a systematic manner (for any country or currency block). Hence, we start first by seeing what objectives this discussion paper assigns to a potential US CBDC, which, among other things, are to (i) not replace current forms of money and financial services provision, (ii) protect consumers' privacy and, at the same time, (iii) protect against AML/CFT issues. Assuming that objectives listed first are (at least marginally) more important to the Fed than the ones

[18] Obviously, we may read it wrong. Hence, this section is merely a demonstration of our CBDC Design Toolkit, not an actual policy analysis.

listed afterwards, our CBDC Design Toolkit shows that (i) and (ii) can indeed be achieved together. But after choosing (ii) as a second priority objective, it seems that achieving (iii) is no longer possible[19], at least achieving it "more effectively than alternative methods", something that the Fed itself requires (Board of Governors of the Federal Reserve System, 2022). This is the first incompatibility (i.e. tradeoff) that seems to have been missed or not discussed. Thanks to our toolkit, we can easily spot such issues. Indeed, as emphasized by BIS Innovation Hub (2023a), "[b]alancing privacy with desired features such as financial integrity and security is challenging". Even if the technology seems promising, we are still not there yet.

With this motivation we go deeper into the discussion paper and based on it create a (sequential) list of objectives that the US CBDC is supposed to achieve, at least according to our way of reading the discussion paper. This list of objectives then gives us a list of necessary design choices to achieve them. These design choices, in turn, give another list of objectives, which are not achievable within the current technology (as captured by our calibration of the toolkit model). See Figure 5 for an overview of the result from our CBDC Design Toolkit applied to the US case.

Figure 5 – Probable CBDC tradeoffs for the US: achievable objectives, design needs and unachievable objectives

Objectives to be achieved	
Objective #1	Minimize FIN - Financial disintermediation
Objective #2	Minimize PAY - Driving private payment systems out
Objective #3	Minimize PAY - Privacy concerns
Objective #4	Minimize PAY - Supporting illicit activities
Objective #5	Minimize FIN - Bank run
Objective #6	Benefit PAY - Supporting innovation
Objective #7	Benefit PAY - Cross-border payments
Objective #8	Minimize MP - Reducing monetary policy independence
Objective #9	
Objective #10	
Objective #11	
Objective #12	
Objective #13	
Objective #14	
Objective #15	

Needed design choices	
Anonymity	Partial
Decentralization	Partial
Retail	Yes
Remuneration	Partial / No
Indirect / hybrid	Yes
Quantitative limits	Yes
Offline	Neutral
Programmable	Yes
Instant	Neutral
Fees	Neutral

Objectives given up
Benefit MP - Fighting currency substitution
Benefit MP - Improving monetary transmission
Benefit MP - Seigniorage income
Benefit MP - Dealing with effective lower bound
Benefit MP - Making helicopter drops easier
Benefit FIN - Stability of payment systems
Benefit FIN - Existence of outside money
Benefit FIN - Fighting currency substitution
Benefit FIN - Financial inclusion
Benefit FIN - Smaller informal economy
Benefit FIN - Lower counterparty risk
Benefit FIN - Information for regulators
Benefit PAY - Convenience
Benefit PAY - Anonymity in digital payments
Benefit PAY - Reducing cost of cash
Benefit PAY - Reducing transaction costs
Benefit PAY - Countering illicit activities
Benefit PAY - Consumer protection
Minimize FIN - Systemic risk of payment systems
Minimize FIN - Financial exclusion
Minimize PAY - Technological risks

Source: authors' construction

Looking at this "3-dimensional" view of the US CBDC, we uncover the following tradeoffs (likely overlooked or underappreciated by the discussion paper at that time):

1) As also discussed above, the first incompatibility is not being able to increase consumer privacy with CBDC as well as better countering illicit activities with CBDC at the same time. Again, the tradeoff is doing each of these two better than existing systems do, since CBDC was

[19] A tradeoff is not between maintaining the same degree of privacy and not messing up AML/CFT side, but it is between increasing privacy protection and increasing AML/CFT protection, relative to the status quo.

sometimes purported as beneficial to achieve these two objectives. Again, BIS Innovation Hub (2023a) has emphasized this particular tradeoff itself[20]. Namely, if privacy in case of the US CBDC would mean identifiable payment data stored at a payment service provider (a commercial bank), with the aim of not allowing a spike in AML/CFT risks, then we are not really improving on privacy or AML/CFT fronts relative to the status quo[21].

2) The next incompatibility we find in the discussion paper is the hope to achieve financial inclusion with the CBDC, when the authors have already assigned objectives of supporting privacy and innovation to their CBDC. The latter (privacy and innovation) require indirect CBDC approaches, while the former (better financial inclusion) may not be possible with an indirect CBDC, at least not more efficiently than with existing payment systems. With its digital euro project, the ECB argues to be achieving all three, viz. financial inclusion, privacy and innovation (European Central Bank, 2023). However, like with the envisioned digital dollar, this seems a fallacy. Financial inclusion most likely requires the Fed or ECB to provide wallets/accounts directly without any intermediary to *some* customers. This, in turn, violates the principle of privacy, if AML/CFT checks are to be respected[22]. In other words, once avoiding a rise in AML/CFT risks becomes a priority objective along with privacy (requiring intermediaries like banks), financial inclusion becomes difficult.

3) Another important tradeoff that we uncover (again, not discussed in their paper) is impossibility to achieve the following two objectives simultaneously: avoiding an increase in the incidence of bank runs and making sure the public always has unlimited access to some form of outside money (i.e. money issued by the central bank). The main reason is their incompatibility with respect to quantitative limits on CBDC holdings. Avoiding bank runs may only be possible by imposing quantitative limits "when agents seek safety at almost any price" (BIS, 2018). On the other hand, if cash usage declines, forced by future digital infrastructures necessarily requiring digital payments/tokenization, and the public would still want a continued access to central bank money (like cash today, which one can hold in unlimited amounts, theoretically), then CBDC should not have quantitative limits on holdings[23].

[20] See also a report on Project Polaris (BIS Innovation Hub, 2023b): "Some design choices limit others. For example, a *high level of privacy could affect how suspicious actions in the system are detected* and countered. Central banks need to consider which choices are most important to them, accepting that there may be trade-offs." (*emphasis own*).

[21] This is already how the current system operates (private data being managed by banks who also do AML/CFT checks).

[22] If people can obtain digital euros from post offices without revealing their identities, how can AML/CFT risks be minimized?!

[23] Of course, apart from the digital side, it is possible (and likely much cheaper) to strengthen the position of cash as legal tender.

4) The next comes a tradeoff between avoiding bank runs and making the US CBDC support the dollar's global reserve currency status (i.e. an opposite to asset/currency substitution), both being objectives that the Fed paper lists. The incompatibility, again, comes from CBDC holding limits. Avoiding banks runs necessitates CBDC holding limits, while competing with foreign monies requires the US CBDC not to impose such limits and allow unlimited cross-border usage, also in developing economies. CBDC caps would incentivize the rest of the world that relied on US dollar cash or deposits to switch to other country CBDCs or stablecoins if a digital future necessitates a tokenized form of a reserve currency (see BIS, 2023 for a vision of the future monetary system) that can be held in sufficient amounts.

5) Still another important tradeoff is the one between achieving the above-mentioned objectives of the US CBDC (that, in addition to the "do no harm" principle, includes supporting innovation) and, at the same time, maintaining high degree of cyber resilience. To be fair, this is something that the discussion paper also mentions itself saying, "[d]esigning appropriate defenses for CBDC could be particularly difficult because a CBDC network could potentially have more entry points than existing payment services." For instance, one potential entry point for smart contract-enabled CBDC is oracles (external sources of information), creating cyber risks (WEF, 2020)[24].

6) Finally, some other objectives are also incompatible with the purported US CBDC, even if those objectives have not been explicitly listed as desirable in the discussion paper. These other incompatible objectives are (see Mkhatrishvili and Boonstra, 2022 for details):

   i. Since the Fed's priority objectives require no (or very little) remuneration of the CBDC, monetary policy transmission cannot be improved by having bigger effect, for instance, on retail deposit interest rates.

   ii. Explicitly trying to limit CBDC take-up (to avoid financial disintermediation), the Fed won't be enjoying a boost in seigniorage (which would have increased if take-up of its CBDC had been high and interest rates on CBDC would be substantially lower than market rates.).

   iii. Some have also argued that a CBDC can help relieve the effective lower bound problem if it would be allowed to pay negative interest, but that's not the case with the envisioned CBDC of the Fed paper that would need quantitative caps on CBDC holdings, which, in turn, limits its impact on market rates.

[24] But, of course, the same risk applies to similar (smart contract-enabled) payment solutions offered by private entities as well.

iv. Due to the same reasons of why improving financial inclusion will be difficult with the above design choices, making helicopter drops more easily will also be less achievable, even if some have assigned this benefit to a CBDC.

v. Achieving more resilience and stability of payment systems may also become difficult with quantitative caps on CBDC holdings. If retail tokenized money becomes a key part of the future monetary system, then capped CBDC may incentivize usage of money issued by a couple of "too big to fail" BigTech companies.

vi. Even though holding limits are meant to limit take-up at the expense of banks' deposits, it also limits take-up at the expense of cash, which is a key source of informality of the economy. Hence, reducing the share of informal economy may also be less achievable with a capped CBDC.

vii. If quantitative limits on the US CBDC would be too small to let some transactions within smart contracts be settled, then the CBDC won't be able to reduce some types of counterparty risks. For instance, when selling a house or a car (relatively high value retail transactions), one may want to incorporate a logic of a change of ownership contingent on payment (atomic transaction[25]), which, whenever possible, would eliminate counterparty risk. Of course, there are similar solutions already in the market (escrow accounts), but they do not work well in every country and we include this point on atomic transactions for the completeness.

viii. Some have argued that a CBDC will give regulators real-time information on the economy and improve their agility (Keister and Monnet, 2022). However, this presumes a direct CBDC (where all the information is at the central bank) and this is incompatible with the aim of improving innovation which, on the other hand, requires an indirect/intermediated CBDC.

ix. Convenience to consumers depends on how freely they'll be using a CBDC, which is incompatible with the aim of limiting bank runs that necessitates CBDC holding limits.

[25] For example, Ann wants to buy a house from Bob, but with simple payments there would be a counterparty risk. If Ann transfers money first she runs the risk that Bob may no longer transfer the ownership of the house in the public registry. On the other hand, if Bob transfers the ownership of the house to Ann, he runs the risk that Ann may no longer transfer the money. Instead, within a programmable infrastructure, money can be programmed in a way that a transfer of money will go through if and only if there would be a transfer of house ownership AND the transfer of house ownership will happen if and only if there would be the transfer of payment. Smart contracts allow this two actions to be bundled as one (the so called atomic transactions) with little cost.

True, the so-called "waterfall" approach may partially solve this issue for many users, but not for all (especially those that are unbanked or underbanked[26]).

x. Costs involved in cash management/infrastructure (printing, distribution, handling) can also be reduced if a CBDC substitutes cash to a large extent[27], but that will be impossible with CBDC holding limits aimed at moderating bank run risks.

xi. Reducing fees associated with retail payments done by private intermediaries can also be achieved by a CBDC competing with them, but this may require a central bank being the primary operator of the CBDC (i.e. direct or centralized approach, competing with intermediaries), which is incompatible with many other objectives (like supporting innovation) that require decentralized and indirect/intermediated approaches. It is also incompatible with other tasks of the central bank like supervision – who would supervise the supervisor? See Boonstra (2019) for such institutional issues.

xii. A privacy-preserving CBDC directly handled (mostly) by a central bank may give consumers power to monetize their payment data[28] (which is currently not the case). But this is less of a possibility if all the consumer-facing activities are done by the same intermediaries (needed for not encouraging financial disintermediation) that currently "freely" exploit these payment data.

xiii. While we mentioned above that the purported US CBDC will probably not be able to increase financial inclusion on its own, in fact, it may even generate further financial exclusion, mostly for elderly. Namely, people who can't/don't use digital products may be marginalized from a digital economy, which will become bigger especially if a CBDC is introduced with an innovation support in mind.

These tradeoffs are created by a specific set of design choices (necessitated by/consistent with priority objectives), which are: partial anonymity (i.e. privacy), partial decentralization, retail, partial or no remuneration, indirect/hybrid approach, with quantitative limits and programmable. At the same time, these design choices allow the US CBDC to achieve some other objectives (which the discussion paper hasn't explicitly mentioned) in addition, like: not exacerbating interest rate lower bound problem, not increasing exchange rate volatility, minimizing state footprint in credit allocation, not worsening

[26] Naturally, unbanked and underbanked consumers will also find it difficult to benefit from a CBDC project if it is within an indirect model.

[27] Of course, declining cash usage doesn't mean abolishing cash altogether. In fact, most central banks have promised to continue providing cash whenever demanded, since it is the ultimate back-up.

[28] A consumer monetizing its own payment data means exerting pressure on a payment service provider/bank to lower a transaction price or improve services and agreeing to share his/her own payment data in exchange (the latter naturally being used by PSPs/banks to their advantage). See Garratt and Lee (2021).

the fundamental/institutional position of the central bank or not increasing systemic risk of payment systems.

All of these tradeoffs are of crucial importance but we think have not been systematically analyzed in anywhere near sufficient degree by the discussion paper (or any other paper that we are aware of). But our CBDC Design Toolkit is developed exactly for that purpose (systematic analysis of CBDC tradeoffs) and this subsection proves its usefulness: identifying 18 key tradeoffs that were not mentioned in the discussion paper (even if they did have some of them in mind). Bottom line of this particular application of the toolkit is that, the Fed's conservative approach makes their envisaged CBDC be able to achieve only two new goals (supporting innovation and cross-border payments), while the rest of their objectives are designed just to not mess up things relative to the status quo.

This exercise also demonstrates how difficult it is to make a CBDC appealing to every policy-maker and explains why there are so starkly opposing views on the topic. Staying on the US CBDC, for instance, compare one Fed official (Brainard, 2022) speech "Preparing for the Financial System of the Future" with another Fed official (Waller, 2021) speech "CBDC: A Solution in Search of a Problem?".

3.2. **Georgia** *(small open emerging economy)*

The National Bank of Georgia (NBG) is also considering an introduction of a CBDC having some specific objectives in mind, as documented by the Public Note of the National Bank of Georgia (NBG, 2023). The NBG has already chosen a technology partner (Ripple) to proceed with its pilot project so that it can "learn by doing" and see how well a CBDC addresses "most relevant use cases for the local landscape". Since the NBG has identified "several gaps" already in this Public Note, it can relatively easily be decided what objectives the Georgian CBDC is supposed to have, but we still need to make some assumptions on the *priority* of each of these objectives. Just like for the US case, our assumptions may not be in line with the eventual decisions of the NBG. Instead, this exercise merely demonstrates the usefulness of our CBDC Design Toolkit.

The NBG clearly states that supporting innovation is one of the top priority objectives of the Georgian CBDC, along with improving payment system efficiency (e.g. reducing transaction costs). The Public Note then goes on and mentions improved access to financial services (financial inclusion) and improving monetary policy transmission mechanism as desirable objectives. It is also mentioned that the CBDC should have "no detriment to financial stability and intermediation" (NBG, 2023), meaning minimizing risks of bank runs and financial disintermediation. Georgian CBDC is also expected to be "instantaneous, widely adopted, low-cost, secure, and reliable", meaning convenience to users and minimal cyber risks. Reducing the cost of cash maintenance is another listed objective, as well as improving on cross-border payments, enhancing payment systems stability and minimizing financial crime/illicit activity. Figure 6 summarizes the resulting tradeoffs and needed design choices, both of which we discuss below.

Figure 6 – Probable CBDC tradeoffs for Georgia: achievable objectives, design needs and unachievable objectives

Objectives to be achieved	
Objective #1	Benefit PAY - Supporting innovation
Objective #2	Benefit PAY - Reducing transaction costs
Objective #3	Benefit MP - Improving monetary transmission
Objective #4	Minimize FIN - Financial disintermediation
Objective #5	Benefit PAY - Reducing cost of cash
Objective #6	Benefit PAY - Cross-border payments
Objective #7	Benefit FIN - Stability of payment systems
Objective #8	Minimize PAY - Supporting illicit activities
Objective #9	
Objective #10	
Objective #11	
Objective #12	
Objective #13	
Objective #14	
Objective #15	

Needed design choices	
Anonymity	Partial
Decentralization	Partial
Retail	Yes
Remuneration	Partial
Indirect / hybrid	Yes
Quantitative limits	No
Offline	Partial / Yes
Programmable	Yes
Instant	Partial / Yes
Fees	No

Objectives given up
Benefit MP - Seigniorage income
Benefit MP - Making helicopter drops easier
Benefit FIN - Financial inclusion
Benefit FIN - Lower counterparty risk
Benefit FIN - Information for regulators
Benefit PAY - Convenience
Benefit PAY - Anonymity in digital payments
Benefit PAY - Countering illicit activities
Benefit PAY - Consumer protection
Minimize MP - Exchange rate volatility
Minimize FIN - Bank run
Minimize FIN - State footprint in credit allocation
Minimize FIN - Financial exclusion
Minimize PAY - Technological risks
Minimize PAY - Cost of operating CBDC infrastructure

Source: authors' construction

Based on our calibration of the toolkit and our reading of the NBG priorities, it seems the Georgian CBDC is likely to face the following kind of tradeoffs:

1) Supporting innovation requires a fully indirect CBDC where financial intermediations have a sufficiently big role in CBDC distribution, while a central bank has no interaction with non-financial entities and households. This may interfere with financial inclusion objective for households that presently are underserved by financial intermediaries. Digital euro tries to remedy this by ECB offering CBDC to people via post offices (European Central Bank, 2023), but this complicates AML/CFT issues as discussed above.

2) Improving monetary policy transmission, another priority objective, could, in principle, make bank runs more problematic, since improving transmission requires no quantitative limits of CBDC holdings, while the objective of minimizing bank run risks necessitates such limits.

3) Supporting innovation requires a distributed CBDC system, while enhancing consumer convenience may be difficult to achieve with such CBDC. Indeed, "improving user convenience by making offline and peer-to-peer payments possible would necessitate additional safeguards to counter the risk of fraud, since security features and centralised controls (eg. to 'lock' stolen funds or query suspicious transactions) are more difficult to implement on a distributed system" (Group of Central Banks, 2020).

4) Supporting innovation requires usage of new technologies which naturally have technological and cyber risks, especially when innovative solutions incorporate usage of oracles, representing a particularly challenging exposure/attack vector.

5) In addition to the above tradeoffs (between different objectives explicitly listed in the Public Note), there are other (implicit) tradeoffs as well:

i. If the NBG were to also prioritize increasing seigniorage income, this would likely not be possible as long as monetary policy transmission improvement remains an objective. The reason is that enhancing transmission requires sufficiently high remuneration of CBDC, which generates interest costs for the central bank, hurting seigniorage.

ii. Making helicopter drops easily (as some imagined to be beneficial, especially during COVID-19) would still be difficult with a fully intermediated CBDC, since some users may remain under-served by financial intermediations, just like today without a CBDC.

iii. Lowering counterparty risk seems to require full decentralization and usage of DLT, to allow for atomic transactions. But transaction costs' reduction may be at odds with this objective, depending on how far a respective technology will develop.

iv. As for the objective of improving information acquisition by regulators, this requires a CBDC not to be fully intermediated, so that sufficiently large number of transactions go through the regulator. But this is at odds with innovation objective, which requires fully intermediated approach.

v. Full anonymity is clearly at odds with many other objectives, especially with the one of minimizing illicit activities, making helicopter drops easier, and improvement of monetary transmission.

vi. Fighting AML/CFT risks more directly requires a direct CBDC as well, which is not compatible with many other aims, like supporting innovation or minimizing financial disintermediation, which necessitate intermediated CBDC.

vii. As discussed by Kahn et al (2021), for instance, consumer protection can be enhanced by offline CBDC with expiry dates, but this means applying very recent technologies, with which defending consumer rights may be difficult unless the system is not fully indirect. But the latter would make the above objectives unreachable.

viii. Exchange rate volatility could become higher unless CBDC holdings/conversions have some quantitative limits. But the latter design will make improving monetary policy transmission much more difficult.

ix. Since the above priority objectives necessitate not much quantitative CBDC limits, this then generates a risk that the state (of course, via central bank) may end up involved in credit allocation. In other words, high demand for CBDC may force a central bank to accept risky collateral in liquidity provision, which amounts to credit allocation (see Mkhatrishvili and Boonstra, 2022).

x. Supporting innovation necessitates such design that may be difficult to absorb by some groups of society (e.g. elderly) and this could complicate the objective of not generating additional financial exclusion.

xi. To effectively reduce transaction costs it is necessary that the central bank incentivize using no fees for CBDC transactions, but this means someone (i.e. taxpayers) should bear overall costs of the whole CBDC infrastructure and development.

These tradeoffs are generated by a need of Georgian CBDC having the following design: partially anonymous (i.e. third party privacy), partially decentralized, retail, with partial remuneration, fully indirect, with no significant quantitative limits eventually, allowing (at least partial) offline functionality, programmable, (close to) instant, with no fees. On the bright side though, while there are 15 tradeoffs listed above, these design choices will allow the NBG to also achieve some other objectives not mentioned in the Public Note. These are: fighting currency/asset substitution (which help both monetary policy as well as financial stability), reducing the size of informal economy, minimizing systemic risk of payment systems, avoiding worsening of the institutional position of the central bank, maintaining access to outside money even in digital world or not exacerbating the lower bound problem on interest rates.

A final comment on this particular example of applying our CBDC Design Toolkit is that, while there are clearly large number of tradeoffs involved, they are somewhat less severe relative to the US (big advanced economy) case, which explains why emerging market economies have been more active on the CBDC research front. Notwithstanding this, tradeoffs that need further scrutiny are still there, making the final decision about issuing a CBDC still difficult and time consuming.

4. Concluding remarks

While many central banks have been advancing their CBDC projects for many years, there has not been done a systematic analysis of all the tradeoffs they will be facing down the road. That's why it's taking so much time to make a decision on the CBDC project. We try to partially fill this void by building a CBDC Design Toolkit. This toolkit systematizes and structures the discussion around CBDC design by showing that prioritizing some objectives (1st "dimension") necessitates specific design choices (2nd "dimension") that, in turn, make another long list of objectives impossible to achieve (3rd "dimension"). After applying this toolkit to a couple of country cases, we uncover a combination of more than a dozen of tradeoffs that each of the central banks has likely missed in their CBDC-related official publications. Indeed, spotting 18 tradeoffs of a CBDC (like we did for the US) or 15 of them (like we did for Georgia) without a toolkit is very difficult. That's what our CBDC Design Toolkit is for.

At the same time, these exercises demonstrated how difficult it is to make a CBDC appealing to every policy-maker (thanks to so many tradeoffs) and explains why there are so starkly opposing views on

the topic. We hope our toolkit helps others as well in navigating this complicated web of CBDC tradeoffs. In addition, these applications (comparing the US case versus the Georgian case) show why emerging market economies may be more active in CBDC projects relative to advanced economies – as their priority objectives may have slightly less tradeoffs.

Last but not least, CBDC projects have another important question to answer: is it a cost-effective way of achieving the accompanying objectives? Policy makers will need to take costs of this project as well as alternative solutions into account, but this question is beyond this article. While we try to help central banks in navigating the question of "what can and cannot be achieved with CBDC and how to achieve them", our toolkit doesn't say much about "what market-offered alternatives are there to achieve the same objectives". Addressing the latter question in a similarly systematic manner remains for the future research.

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