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Greening capital requirements

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Summary

Capital requirements play a central role in financial regulation and have significant implications for financial stability and credit allocation. However, in their existing form, they fail to capture environment-related financial risks and act as a barrier to the transition to an environmentally sustainable economy.

Environmental issues can be incorporated into capital requirements using three different approaches: (i) microprudential approaches, which suggest that capital requirements need to be adjusted based on micro-level exposures to environmental risks; (ii) weak macroprudential approaches, which emphasise the exposure of financial institutions to systemic risks linked to specific sectors and geographical areas; and (iii) strong macroprudential approaches, whereby systemic risks are analysed by explicitly considering macrofinancial feedback loops and double materiality.

In the age of environmental crisis, strong macroprudential approaches should play a prominent role in the greening of capital requirements. Green differentiated capital requirements (GDCRs) are one of the tools that are consistent with a strong macroprudential approach. If designed to accurately capture the environmental footprint of bank assets and minimise adverse financial side effects, GDCRs can contribute to the greening of the banking system and the reduction of physical risks. The positive effects of GDCRs can be enhanced if they are combined with other financial and non-financial environmental policy tools.

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This paper is part of a toolbox designed to support central bankers and financial supervisors in calibrating monetary, prudential and other instruments in accordance with sustainability goals, as they address the ramifications of climate change and other environmental challenges. The papers have been written and peer-reviewed by leading experts from academia, think tanks and central banks and are based on cutting-edge research, drawing from best practice in central banking and supervision.

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1. Introduction

Interest in the implications of the environmental crisis for financial regulation has grown in recent years. Several policymaking institutions have recognised the need to make financial regulation climate-aligned (e.g., Dombrovskis, 2017; EBF, 2017; European Commission, 2018; Bank of England, 2021; ECB, 2022). As a central element of financial regulation, capital requirements have been prominent in debates about how financial regulators should respond to the environmental challenges that we are facing.

"Existing capital requirement frameworks are inconsistent with the targets of the Paris Agreement."

The existing capital requirement frameworks have been criticised from an environmental perspective for two reasons. First, they do not explicitly address the exposure of financial institutions to environment-related financial risks. These risks are material and imply that financial institutions might currently be under-capitalised. Second, the way in which capital requirements are determined does not incentivise banks to increase the financing of green activities and does not penalise banks for supporting activities that are inconsistent with the targets of the Paris Agreement.

This paper conceptually analyses how capital requirements can become green and explores how green differentiated capital requirements (GDCRs) can be incorporated into financial regulation frameworks. We proceed as follows. Section 2 explains why the lack of environmental considerations in existing capital requirements frameworks is problematic. Section 3 compares and contrasts different approaches for the incorporation of environmental considerations into capital requirements, paying particular attention to the distinction between microprudential and macroprudential approaches. Section 4 focuses on the potential macrofinancial and environmental effects of GDCRs. Section 5 discusses implementation issues and practical challenges related to the use of GDCRs. Section 6 concludes.

2. Why are existing capital requirements frameworks problematic from an environmental perspective?

Capital requirements are at the core of Basel III – the current international regulatory accord that drives financial regulation around the world. Their key purpose is to make sure that financial institutions hold sufficient capital to protect themselves from exposure to financial risks. According to Basel III, financial institutions' capital adequacy ratio (defined as the ratio of bank capital to risk-weighted assets) needs to be at least equal to 8% (see BCBS, 2010b).[1] However, financial institutions might be asked to hold additional capital because of the following elements of Basel III (see BCBS, 2010b; 2013):

- The capital conservation buffer, according to which banks should hold additional Common Equity Tier 1 capital equal to 2.5% of their risk-weighted assets.
- The countercyclical capital buffer, a time-varying capital requirement that ranges between 0% and 2.5% of risk-weighted assets depending on whether an economy faces excessive credit growth.[2]
- The Global Systemically Important Banks (G-SIBs) capital requirements. These enable regulators to ask G-SIBs to hold additional Common Equity Tier 1 capital that ranges between 1% and 3.5%.[3]
- The Basel III leverage ratio (defined as the ratio of Tier 1 capital to total exposure), which suggests that banks' capital-to-total-assets ratio should be at least equal to 3%.

In several jurisdictions, banks might be asked to hold even more capital to address specific types of risks. In the EU, for instance, financial institutions that are deemed to be exposed to economic activities and geographical areas that are particularly risky might be asked to hold additional capital, according to the systemic risk buffer.[4]

[1]Bank capital includes both Tier 1 capital (e.g. shareholders' equity and retained earnings) that is considered to be high-quality capital and Tier 2 capital (e.g. subordinated term debt to depositors and revaluation reserves) that is of lower quality compared to Tier 1 capital.

[2]National authorities decide whether there is excessive credit growth in their economies using several indicators, such as the credit-to-GDP gap (see BCBS, 2010a; Bank of England, 2016).

[3]Basel III identifies G-SIBs using several criteria, such as interconnectedness, complexity and bank size.

[4]For example, at the time of writing, several EU countries require banks to hold additional capital against retail exposures secured by residential property.

The risk weight of assets is estimated by considering the market and credit risks that assets face: the higher the risks, the higher the capital that banks need to hold against these assets. However, the risk models that are currently used to estimate capital requirements have not explicitly incorporated environmental risks, which include both transition risks (risks related to an abrupt transition to an ecologically sustainable economy) and physical risks (risks for the financial system that stem from climate-related events and other environmental issues like biodiversity loss).

Both transition risks and physical risks are material. For example, the EBA (2021) has shown that about 60% of EU corporate loans have been provided to Climate Policy Relevant Sectors (CPRS), i.e. sectors that are exposed to climate transition risks (see Battiston et al., 2017). Alogoskoufis et al. (2021) have shown that a significant proportion of EU banks' loans are exposed to the physical risks of floods, water stress, heat stress, wildfires and other climate-related events. UK banks are also significantly exposed to flood risks and sea level rise, according to the recent climate stress testing exercise by the Bank of England (see Bank of England, 2022). The fact that current regulatory frameworks do not incorporate these risks into capital requirements implies that banks might hold insufficient capital and are therefore financially fragile.

However, capital requirements are not only important for protecting banks from exposure to financial risks. The empirical literature has shown that they also have (intended or unintended) implications for the size and terms of credit provision. For example, an increase in capital requirements can induce banks to reduce their lending[5] and increase interest rates.[6] Differentiated capital requirements can also affect the direction of lending. For example, Mayordomo and Rodríguez-Moreno (2018) show that the small and medium enterprises (SME) supporting factor (introduced in the EU in 2014 to support credit provision to SMEs and counterbalance the implications of the capital requirements increase due to the introduction of Basel III) increased the amount of lending provided to medium-sized enterprises. Dietsch et al. (2020) also show that the SME supporting factor had positive effects on the credit supply for SMEs.[7]

The non-neutral effects of capital requirements on bank lending are explicitly recognised in the rationale underlying Basel III's countercyclical capital buffer. One of the reasons banks are asked to hold less capital during recessions (or more during expansions) is to prevent the under-provision (or over-expansion) of credit (see also Dafermos, 2022).

The non-neutral effects of capital requirements on bank lending are also particularly important due to the great deal of financing provided to carbon-intensive companies that have significant responsibility for the environmental crisis. For example, RAN et al. (2022), show that the largest banks around the world (e.g. JPMorgan Chase, Barclays, HSBC) provided $4.6 trillion of fossil fuel financing over the period 2016-2021. Empirical analysis by Alogoskoufis et al. (2021) finds that 40% of banks' portfolios consist of loans to manufacturing, wholesale and retail, transport and electricity and gas, which are the biggest contributors to overall emissions. Chaves et al. (2022) also argue that there is no indication that EU banks are actively greening their portfolio: instead, their portfolios passively reflect the carbon footprint of their borrowers. Therefore, the fact that the existing capital requirements frameworks do not induce banks to reallocate credit towards more environmentally friendly activities encourages the continuation of the financing of dirty activities, and thereby exacerbates the environmental crisis.

"The non-neutral effects of capital requirements on bank lending are particularly important due to the great deal of financing provided to carbon-intensive companies."

[5]See e.g. Bridges et al. (2014), Aiyar et al. (2016), De-Ramon et al. (2016), Meeks (2017), Gambacorta and Shin (2018), Uluc and Wieladek (2018), Gropp et al. (2019), De Jonghe et al. (2020), Fraisse et al. (2020), Juelsrud and Wold (2020) and De Marco et al. (2021).

[6]See e.g. Slovik and Cournède (2011), Akram (2014), Meeks (2017), Barth and Miller (2018) and Juelsrud and Wold (2020).

[7]Note that this comes in contrast to the preliminary evidence provided by EBA (2016), according to which the SME supporting factor did not lead to additional credit availability for SMEs.

3. Incorporating environmental considerations into capital requirements

Capital requirements can be analysed and designed both from a microprudential and a macroprudential perspective.[8] From a microprudential perspective, the main role of capital requirements is to ensure that individual financial institutions have sufficient capital to avoid insolvency problems that might arise in the case of debt defaults. From a macroprudential point of view, capital requirements have a more complex role; they need to be designed in a way that minimises systemic risks for financial institutions, potentially considering financial interconnections and macrofinancial feedback loops.

Table 1 below provides a summary of the main similarities and differences between microprudential and macroprudential approaches in how they incorporate environmental considerations into capital requirements.

Table 1. Comparison of different types of environment-related adjustments to capital requirements

	Main purpose	Consideration of macrofinancial feedback loops	Examples
Microprudential	Reduction of the exposure of individual financial institutions to micro-level environmental risks	No	Adjustments in risk weights based on climate-related credit risks
Weak macroprudential	Reduction of the exposure of the financial system to sector- or region- specific environmental risks	No	Climate systemic risk buffer; carbon-intensive leverage ratio; climate concentration charge
Strong macroprudential	Contribution to the reduction of systemic environmental risks	Yes	Green differentiated capital requirements

"The greening of capital requirements can be analysed and designed both from a microprudential and a macroprudential perspective."

In an environment-adjusted microprudential framework, financial institutions need to analyse their exposure to environmental risks and, if necessary, reduce their exposure to these risks by holding higher capital (see NGFS, 2022).

In the case of macroprudential frameworks, a distinction can be made between *weak* and *strong* approaches to environment-related adjustments. In the weak version, the financial system needs to protect itself from exposure to systemic environmental risks. Such systemic risks can stem from exposure to carbon-intensive sectors or to geographical areas that are characterised by high physical risks (see Monnin, 2021). However, this approach does not pay specific attention to the feedback effects that banks' behaviour has on the macroeconomy and the materialisation of risks.

In the strong macroprudential approach, the feedback effects of the financial system matter. The question is not just how exposed banks are to micro-, sectoral or geographical risks, but also how banks' financing practices can affect these risks via feedback loops. This is in line with the principle of double materiality, which highlights that the environment poses risks to the financial system, but at the same time the financial system can affect environmental outcomes, which in turn affect the risks that banks are exposed to.[9] The strong macroprudential approach therefore explicitly accounts for the endogeneity of environmental risks (see Battiston et al., 2021 and Dafermos, 2022 for more on this endogeneity). According to a strong

[8]For the difference between microprudential and macroprudential approaches, see Hanson et al. (2011), Galati and Moessner (2013) and Yilla and Liang (2020).

[9]For a description of the concept of double materiality, see Adams et al. (2021), Oman and Svartzman (2021) and Täger (2021).

macroprudential approach, physical risks should not be viewed as exogenous to the lending practices of banks; if banks provide loans to carbon-intensive companies, they contribute to global warming and therefore to physical risks. Although microprudential and weak macroprudential approaches might also recognise the potential for capital requirements to have environmental and systemic risk implications (see e.g. ECB and ESRB, 2022), this is typically considered a side effect, and not one of the main purposes of financial regulation.

We now turn to the implications and tools of these three types of environment-related adjustments to capital requirements.[10]

"Strong macroprudential approaches to capital requirements explicitly account for the endogeneity of environmental risks."

Microprudential adjustments

From a microprudential perspective, the incorporation of environmental risks into capital requirements is, in theory, straightforward: the risk models used to determine capital requirements should be modified to explicitly capture the transition and physical risks of specific assets at the micro level. However, in practice it is very challenging to quantify environmental risks. This is mainly because environmental risks of the past are not a good guide for the future. For instance, past data about green assets and dirty assets might show that there is no risk differential between these two types of assets (see e.g. NGFS, 2020). However, in a scenario where carbon prices increase quickly and abruptly in the future, financial risks related to dirty assets could become much higher than those of green assets.

The climate stress testing exercises recently conducted by central banks and financial supervisors are based on scenario analyses (e.g. Banque de France and ACPR, 2021; Alogoskoufis et al., 2021; Bank of England, 2022) and can help to quantify environmental risks. However, translating these quantified risks into capital requirements poses another set of practical challenges. Specifically, it is not straightforward for financial regulators to determine which climate scenario they should use as a basis for the adjustment of capital requirements, nor is how to deal with the uncertainty that characterises the quantification of climate risks – which is much higher than the uncertainty that characterises traditional financial risks. In addition, the data requirements for capturing climate risks at a micro level are very high, which can be a significant barrier to the implementation of microprudential-oriented adjustments to capital requirements. Crucially, the data and modelling requirements are even higher in the case of non-climate environmental risks (see Kedward et al., 2022).

Weak macroprudential adjustments

The distinct feature of the weak macroprudential adjustments compared with the microprudential ones is that the exposure of banks is evaluated based on the features of specific groups of assets, not based on the micro-characteristics of assets. These groups of assets can, for example, be the assets of carbon-intensive sectors, the assets of sectors that are particularly exposed to water stress, or the assets of companies that are located in coastal areas particularly exposed to flood risk or sea level rise.[11]

Policy proposals that are in line with the weak macroprudential approach include:

- climate systemic risk buffers, according to which financial regulators should ask banks to hold additional capital (relative to their risk-weighted assets) if the latter have sufficiently high exposure to groups of assets that are characterised by high physical or transition risks (Schoenmaker and van Tilburg, 2016; Monnin, 2021; ECB, 2022);
- a carbon-intensive leverage ratio that suggests that banks' Tier 1 capital compared to their carbon-intensive assets should be higher than a specific threshold (D'Orazio and Popoyan, 2019);

[10] Berenguer et al. (2020) make a distinction between the 'risk approach' and the 'economic policy approach' to the environmental adjustment of capital requirements. The 'risk approach' is more in line with the environment-adjusted microprudential framework and the weak environment-adjusted macroprudential approaches. The 'economic policy approach' is more consistent with the strong version of the environment-adjusted macroprudential approach.

[11] ECB (2022) has recently emphasised the potentially important role that weak macroprudential regulatory tools can play in addressing environmental risks (see also Emambakhsh et al., 2022).

- a climate concentration charge that can take the form of a risk weight add-on that is applied when climate-related exposures exceed a specific threshold (ECB, 2022); and
- a carbon-intensive countercyclical capital buffer according to which banks should be asked to hold more capital when the carbon-intensive credit-to-GDP ratio is higher than its trend (D'Orazio and Popoyan, 2019).

An advantage of the weak macroprudential approaches over the microprudential ones is that they are simpler to implement. In weak macroprudential approaches, the estimation of capital requirements relies on group-level information about the assets and does not necessarily require the use of detailed scenario analysis, as is the case in microprudential approaches. However, this carries the drawback that weak macroprudential approaches may not accurately capture climate risks. For instance, companies located in the same geographical area might be grouped together, but their different business models and different levels of investment in climate adaptation mean that they face very different physical risks.

Strong macroprudential adjustments

Strong macroprudential approaches place emphasis on what banks can do to reduce physical and transition risks at the system level. Their aim is, therefore, to adjust capital requirements in a way that incentivises banks to support the ecological transition and the resilience of the economy to climate change. From a strong macroprudential perspective, the question is not whether green assets are less risky than dirty assets at the micro level, but how best to capture the 'greenness' and 'dirtiness' of assets in order to properly incentivise the reallocation of finance away from environmentally-harmful activities.

"Strong macroprudential approaches aim to adjust capital requirements in a way that incentivises banks to support the ecological transition and the resilience of the economy to climate change."

Green differentiated capital requirements are one of the tools that can be used to reallocate finance in line with the strong macroprudential approach. They take two forms: the green supporting factor (GSF) and the dirty penalising factor (DPF) (see Dafermos and Nikolaidi, 2021). The GSF reduces the risk weight on green loans while the DPF increases the risk weight on dirty loans. GDCRs therefore make green loans more affordable than dirty loans, incentivising banks to: (i) provide more green loans vs. dirty loans; and (ii) increase interest rates on dirty loans vs. those of green loans. This can contribute to the reduction of emissions and other negative environmental effects, making physical risks lower in the long run. By accelerating the decarbonisation of the financial system, GDCRs can also make the overall financial system more resilient to climate transition shocks that might stem from climate policies implemented domestically or abroad.

Another proposal that is consistent with the strong macroprudential approach and has recently received significant attention is the 'one-for-one' rule suggested by Philipponnat (2020). According to this rule, for each loan unit provided to fossil fuel projects, financial institutions need to hold an equivalent amount of capital. This rule is thereby a specific form of DPF in which the risk weight of specific carbon-intensive assets increases to its maximum value. One of the main purposes of this rule is to strongly disincentivise financial institutions from financing projects that are clearly inconsistent with the targets of the Paris Agreement. However, the rule has also been justified with reference to risk exposure. If we accept that fossil fuel assets are highly exposed to transition risks because the net zero transition is expected to happen sooner or later, financial institutions should stop investing in such assets without holding an equivalent amount of capital. This is in line with both microprudential and weak macroprudential perspectives.

An example of a specific type of GSF that has recently been implemented is the preferential capital requirements for green housing loans of the Magyar Nemzeti

Bank (MNB) in Hungary (see MNB, 2020). For the period 2020 to 2023, the MNB has lowered the capital requirements linked to energy-efficient properties, using a two-part rationale to justify the policy. First, it wishes to advance the Hungarian financial system's transition to an ecologically sustainable economy – a rationale that is in line with the strong macroprudential approach. However, from a strong macroprudential perspective, higher capital requirements should also have been introduced for energy-*inefficient* properties, and a proper calibration of risk weights would be necessary to avoid a reduction in the capital adequacy ratio of banks (for more on this, see Section 5). The second rationale is that mortgages associated with energy-efficient properties are considered to have a lower financial risk because these properties have, on average, lower energy bills. It is not clear whether this assumption is correct. However, if it is, this policy would be consistent with the microprudential approach (and perhaps also with the weak macroprudential one).

Further considerations

The three different approaches to making environmental adjustments to capital requirements (microprudential, weak macroprudential and strong macroprudential) raise some wider considerations about risks, policy complementarities and the legislative context.

"Strong macroprudential tools need to be utilised in a way that is complementary with microprudential and weak macroprudential tools."

First, the use of microprudential and weak macroprudential tools can lead to an increase in physical risks at the system level by causing financial institutions to reduce their exposure to climate-vulnerable assets (whether households, firms or countries). As a result, climate-vulnerable borrowers' access to climate adaptation finance might decline, undermining their ability to invest in adaptation measures to protect themselves from climate risks. By contrast, the strong macroprudential approach implies that capital requirements might need to be adjusted to promote climate adaptation finance because, from a systems perspective, investment in this is conducive to the reduction of physical risks.

Second, the isolated introduction of a GSF can have adverse financial effects. The introduction of a GSF might lead to the support of projects with the potential to reduce emissions and negative environmental impacts. However, some of these projects might face a high credit risk because they rely on green technologies that could be too risky from a financial perspective (see further discussion in Sections 4 and 5).

Third, strong macroprudential tools need to be utilised in a way that is complementary with microprudential and weak macroprudential tools.[12] The simultaneous use of these tools can minimise unintended adverse effects that may occur if used in isolation. For example, if the implementation of microprudential and weak macroprudential tools over-penalises borrowers that are exposed to physical risks, the simultaneous introduction of a GSF (that has been calibrated to reduce capital requirements for climate adaptation projects) can reduce these penalties to support climate resilience from a systemic perspective. Or, if a GSF is introduced to support green activities based solely on their environmental impacts, the fact that some of these projects may be too risky from a financial perspective can be addressed by the simultaneous use of microprudentially-adjusted capital requirements.

If tools are used in combination, the greening of capital requirements might lead to multiple environment-related adjustments to capital requirements. For instance, if microprudential and strong macroprudential tools are implemented simultaneously, the risk weight of carbon-intensive assets could increase or for two reasons: (i) they might be riskier for banks from a micro perspective; and (ii) contribute to physical

[12]Note that this complementary use would not be new: Basel III has set capital requirements using both microprudential and macroprudential tools.

risks from a strong macroprudential perspective. Also, alternative approaches might lead to very different adjustments in the risk weights of two green assets with the same environmental impact. Although the strong macroprudential adjustments will reduce the risk weight of these assets in the same way, the microprudential ones might work in a completely different direction. This can be the case if, for example, the green investment of the first asset relies on the extraction of minerals and is therefore financially exposed to an increase in carbon prices, but the second asset does not suffer from such an exposure.

Fourth, some tools can be introduced with just a few adaptations to existing instruments (e.g. climate systemic risk buffer), while others require more fundamental changes to legislation. In the case of weak macroprudential tools, the adaptation to legislation required might not be substantial given that the purpose of these tools is to reduce exposure to risk. In this way, they are consistent with the risk-based spirit of prudential regulation. However, the introduction of strong macroprudential tools is more challenging from a legal perspective as it could require either a reference to the endogeneity of systemic environment-related financial risks or to economic policy objectives in the context of the environmental crisis. The examples of the SME supporting factor and the MNB preferential capital requirements for green housing loans mentioned above suggest that it is possible to introduce changes to capital requirements based on policy objectives. The introduction of such tools is also more feasible now due to the net zero emissions commitments of many governments.

Fifth, financial regulators and supervisors can use several tools beyond capital requirements to address environmental issues. These include: climate stress testing; the submission of climate transition plans by financial institutions (Dikau et al., 2021); concentration thresholds that limit exposure to certain geographical areas and sectors; and climate-related liquidity requirements (D'Orazio and Popoyan, 2019; ECB, 2022). These tools can be used in a way that complements capital requirements. In fact, many of these tools can support the better use and calibration of environment-adjusted capital requirements. For example, climate stress tests can allow supervisors to set higher climate-related capital requirements as they see fit, and transition plans can improve climate-related information that is necessary for properly adjusting capital requirements.

"Introducing changes to capital requirements based on environmental policy objectives is more feasible now given the net zero emissions commitments of many governments."

4. Effects of green differentiated capital requirements

GDCRs can affect both credit availability and the cost of borrowing. As we have previously identified, there are four channels through which GDCRs can affect lending practices (Dafermos and Nikolaidi, 2021):

- **Credit volume channel**. GDCRs can affect the capital adequacy ratio. In the case of the GSF, a decline in the risk weight of green loans can increase the capital adequacy ratio, potentially leading banks to provide more credit to the economy. In the case of the DPF, an increase in the risk weight of dirty loans can reduce the capital adequacy ratio, leading to a credit contraction. The magnitude of these effects depends on the sensitivity of lending to changes in the capital adequacy ratio.
- **Credit reallocation channel**. Under both a GSF and a DPF, banks are induced to allocate a greater proportion of their assets to environmentally friendly projects and a smaller proportion to dirty loans. This is because GSF and DPF increase the cost of dirty financing relative to the cost of green financing.

- Cost of borrowing channel. A change in the capital adequacy ratio can affect the overall interest rates that banks charge for their loans. In the case of the GSF, a reduction in the risk weight of green loans increases the capital adequacy ratio, inducing banks to reduce the overall level of their interest rates. The opposite occurs in the case of the DPF.
- Differentiated interest rate channel. Both the GSF and the DPF tend to reduce the interest rate on green loans and increase the interest rate on dirty loans, making green financing relatively cheaper. This is important because the interest rate differential can affect firms' and households' investment plans.

These four channels suggest that, although it is clear that the GSF tends to increase green lending, its impact on dirty lending is more ambiguous. If the credit volume channel is stronger than the credit reallocation channel, dirty lending will increase. If the opposite is true, dirty lending will decline. Also uncertain is the impact on the interest rates of dirty loans, which might increase or decline with the introduction of the GSF, depending on the relative strength of the cost of borrowing channel and the differentiated interest rate channel. Furthermore, for similar reasons, the introduction of a DPF can either increase or decrease green lending and interest rates on green loans. The relative strength of the channels matters.

"GDCRs can reduce physical risks, but they might have adverse transition effects."

We have previously analysed how GDCRs can affect physical and transition risks from a systems-level perspective and have favourable environmental effects through the channels discussed above (Dafermos and Nikolaidi, 2021).[13] These favourable effects can reduce the physical risks that the financial system faces in the long run. Although the effects might not be quantitatively large, they can be reinforced when the GSF and the DPF are implemented simultaneously.

GDCRs can also have transition effects. In particular, the GSF can increase the leverage of banks (i.e. the assets that they hold compared to their capital), making them more financially fragile – see also Matikainen (2017) and Ford (2018) on the potential adverse effects of the GSF on financial stability. Moreover, the implementation of the DPF can lead to reduced economic activity as it prompts banks to provide less lending to dirty companies and charge higher interest rates on dirty loans. This negatively affects firms' profitability and liquidity, with feedback effects on banks' capital. These transition effects are, however, reduced when the GSF and the DPF are used simultaneously (see Dafermos and Nikolaidi, 2021), for two main reasons. First, carbon-intensive firms, which might face a decline in credit availability as a result of the DPF, are able to counterbalance this by investing in green projects for which credit availability will be higher as a result of the GSF. This can prevent a significant deterioration in their liquidity position. Second, a rise in the leverage of banks can be avoided as the increase in green lending can be offset by a reduction in dirty lending.

5. Implementation, practical challenges and policy coordination

We now turn to analyse several implementation issues and practical challenges that financial regulators could face if they decide to introduce GDCRs.

First, in the design and implementation of the GDCRs, financial regulators should identify the environmental footprint of assets using both borrower-level environmental metrics and information about the types of activities that borrowers engage in (see Dafermos et al., 2022a). Borrower-level environmental metrics should rely on both backward-looking and forward-looking indicators. Backward-looking indicators can include, for example, historic emissions reductions, current

[13] Our analysis relies on econometric estimations that are broadly in line with the estimates in Thöma and Gidhardt (2019) and Chamberlain and Evan (2021), who have analysed the potential quantitative effects of GDCRs on credit availability and interest rates.

carbon intensity compared to peers, or the handling of hazardous waste. Forward-looking indicators can include the plans that companies have for reducing their emissions and investment in carbon-intensive activities, and the extent to which these plans are credible and in line with net zero pathways. To capture the dirtiness of the types of activities that companies engage in, activities can be categorised using, for example, the Climate Policy Relevant Sectors (CPRS) classification introduced by Battiston et al. (2017) and further updated and refined in Alessi and Battiston (2022). The greenness of activities can be captured using the EU Taxonomy (European Commission, 2020). On top of this, classifications of activities based on their non-climate environmental impacts, such as loss of pollinators, water scarcity, material depletion and loss of biodiversity, have to be considered (see e.g. UN Environment Programme et al., 2020; NEA, 2021). This is crucial because some activities that are conducive to climate mitigation might have other negative environmental impacts (see Kedward et al., 2022). Financial regulation should therefore not support these climate mitigation activities in the same way as others that do not have such adverse effects.

Based on their environmental footprints, assets can be classified into different environmental 'buckets'. Assets placed into buckets associated with a strong environmental performance can see a reduction in the capital that banks need to hold against them (through a GSF), while assets put into weak environmental performance buckets would need to be penalised via a DPF.

"Financial regulators should identify the environmental footprint of bank assets using both borrower-level environmental metrics and information about the types of activities that borrowers engage in."

Second, GDCRs need to be designed and calibrated so that their introduction does not reduce the overall risk-weighted assets of financial institutions. This is particularly important from a financial stability perspective because if risk-weighted assets decline after the environmental adjustments in risk weights, banks might become under-capitalised and therefore more financially fragile. However, the issue of under-capitalisation might arise only if financial regulators introduce a GSF. There are two possible scenarios: (i) a GSF is introduced in isolation; or (ii) the introduction of a GSF is accompanied by the introduction of a DPF. In the first scenario, the risk-weighted assets will definitely decline, so introducing a GSF in isolation should be avoided. In the second scenario, risk weights should be calibrated such that risk-weighted assets do not decline at the aggregate level. In practice, the simultaneous implementation of a GSF and a DPF is unlikely to reduce risk-weighted assets in the short term. This is because green assets are currently much smaller in size than dirty assets. However, this might change in the medium- to long-term as economies become greener. Therefore, the requirement that environmental adjustments do not lower risk-weighted assets should be a permanent feature of GDCRs. This is also necessary to minimise the risk of green credit booms and avoid green-induced bank under-capitalisation.

Third, financial regulators can capture the environmental impact of corporate loans either based on the environmental footprint of companies (as described above) or based on the environmental impact of specific projects. Although a project-level evaluation might sound more appropriate, it may be difficult for financial institutions to monitor whether the proceeds from a new loan are used for purposes other than financing a specific investment – posing a significant challenge. The introduction of a green loan certification process could help to address this. However, it is more reasonable for the vast majority of corporate loans to be evaluated based on the overall environmental footprint of companies, as this captures the total environmental impact of borrowers and minimises greenwashing risks. In the case of household loans (e.g. mortgages), however, it is necessary that they are evaluated based on how the money received from banks is spent – whether it is used to purchase an energy-efficient house or not, for example.

Fourth, whether the introduction of GDCRs should lead to an adjustment of risk weights for just new loans or also for existing loans is an open question. The advantage of applying the changes to existing loans is that, for those with adjustable interest rates, banks can be induced to adjust interest rates based on the progress that companies and households make in reducing their negative environmental impact. But, most crucially, banks might be encouraged to engage with borrowers, prompting them to reduce their environmental footprint. If borrowers improve their environmental performance, the risk weights of the bank's related assets can go down, reducing banks' capital requirements.

Fifth, regulatory arbitrage, whereby firms circumnavigate unfavourable regulatory conditions, can reduce the effectiveness of GDCRs. For example, if a DPF is introduced only in a specific country, financial institutions might redirect their lending to other countries where a DPF is not in place.[14] The risk of regulatory arbitrage can be reduced if a DPF is introduced simultaneously in many countries. This can be achieved by introducing GDCRs via the Basel framework, for example, as this covers several jurisdictions around the world. It is also crucial that the introduction of GDCRs is built on global coordination as their use across different parts of the world can maximise the favourable effects of global emissions reductions and the lowering of physical risks.

Moreover, companies that might face stricter credit conditions due to the introduction of a DPF could turn to the bond or the stock market to fund their spending. On top of this, financial institutions that might wish to continue to provide dirty financing might use shadow banking practices (such as securitisation) to avoid a rise in their capital requirements due to a DPF. It is therefore essential that environment-related adjustments to capital requirements are combined with other financial and monetary interventions. One example of such interventions is the greening of central bank corporate bond purchases and collateral frameworks such that dirty bonds face stricter financing conditions (see Dafermos et al., 2021, 2022a, 2022b). This would prevent the use of bond financing as an alternative to loan financing. And if these measures also capture shadow banking financial instruments (such as asset-backed securities), they would discourage the reliance on shadow banking practices for funding environmentally-harmful investment. Another example of an intervention that would prevent the use of shadow banking to fund dirty activities is the introduction of environment-adjusted haircuts in the private repo markets (see Gabor et al., 2019).

"It is essential that environment-related adjustments to capital requirements are combined with other financial and monetary interventions."

Sixth, GDCRs can be more effective if they are combined with other environmental policies – beyond those that refer to the financial system and monetary policy. This is straightforward in the case of physical risks. For example, if GDCRs are implemented at the same time as green fiscal policies (like green subsidies or carbon taxation), their beneficial effect on green investment can be enhanced. In the case of transition risks, the implications of policy coordination are a little more complicated. For example, in Dafermos and Nikolaidi (2021), we have shown that the potentially adverse transition effects of a DPF decline if it is implemented in conjunction with green fiscal policies. This is because green fiscal policy decreases the demand for dirty loans and, therefore, the DPF applies to a smaller proportion of loans than if green fiscal policy were absent. However, if green fiscal policy is combined with a GSF, the leverage of banks can increase even further than if a GSF were implemented in isolation. Overall, financial regulators have a strong incentive to coordinate with other policy authorities to ensure that capital requirements are adjusted in a way that can contribute to the reduction of physical risks without creating substantial transition effects.

[14] For the importance of regulatory arbitrage in the case of countercyclical capital buffer, see Bockmeyer (2021).

6. Conclusion

As the environmental crisis deepens, all policymakers need to do their part in the collective attempts to prevent environmental catastrophe. Although financial regulation cannot by itself deal with the environmental crisis, it has a crucial role to play in the broader environmental policy mix and it can be particularly important for achieving the decarbonisation of the financial system that is urgently needed for reducing the growing physical risks.

Capital requirements, which are at the core of financial regulation frameworks around the world, have a significant role in greening the financial system. GDCRs are consistent with a strong macroprudential approach to environmental issues and go further than microprudential and weak macroprudential approaches which focus on the exposure of financial institutions to risks without explicit consideration of macrofinancial feedback loops. Strong macroprudential approaches, however, explicitly take into account that financial actions with positive impacts on the environment can also be good for the long-term stability of the financial system. In the age of environmental crisis, it would be a dangerous omission for financial regulators to ignore this fact.

"Although financial regulation cannot by itself deal with the environmental crisis, it has a crucial role to play in the broader environmental policy mix."

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