Green Monetary Policy -

An Impact Assessment of Green TLTROs*

B.A. Thesis

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List of Abbreviations

BIS	Bank for International Settlements
CDS	Credit default swap
CRFR	Climate-related financial risk
DF	Deposit facility
ECB	European Central Bank
ESG	Environmental, social and corporate governance
EU	European Union
EURIBOR	Euro Interbank Offered Rate
GBB	Green bank bond
GFC	Global financial crisis
GHG	Greenhouse gas
GTLTRO	Green targeted longer-term refinancing operation
GVA	Gross value added
HQLA	High-quality liquid asset
LTRO	Longer-term refinancing operation
MRO	Main refinancing operation
NGFS	Network for Greening the Financial System
NGO	Non-governmental organization
QE	Quantitative easing
SME	Small and medium-sized enterprise
TLTRO	Targeted longer-term refinancing operation

1. Introduction

Green monetary policy refers to contributions in the subject area of monetary economics that regard climate change as a central cause variable on the conduct of monetary policy. Starting from this assessment, green monetary policy scholars analyse central banks' room for manoeuvre. Galvanized by think tanks and NGOs, central banks have recently started to discuss proposals to make monetary policy 'green' (Dikau et al., 2020). According to the European Central Bank's (ECB) latest strategy report, published on July 8th 2021, elements of green monetary policy will be integrated into the ECB's operational framework. The measures the report would advance in the field of green monetary policy were among the topics most fervently debated and hotly anticipated in the run-up (Stiens, 2021; Krämer, 2021). What is now on the ECB's green agenda is as follows: green financial indicators, disclosure requirements, climate stress testing, green asset purchases and a climate-risk sensitive recalibration of its collateral framework (Lagarde, 2021b).

In this paper, I will analyse the potential of green targeted longer-term refinancing operations, henceforth 'GTLTROs' or 'green TLTROs'. GTLTROs are a theoretical proposal that envisages central banks to offer banks[1] funding at concessional lending rates, if banks expand their granting of 'green' credit (van't Klooster & van Tilburg, 2020). Similar green refinancing schemes have been piloted in Brazil, Bangladesh and recently in Japan (Kihara, 2021; Dikau et al., 2020; Barkawi & Monnin, 2015). Although GTLTROs do not feature in the strategy report's green agenda, Christine Lagarde, President of the ECB, has stressed them to be "a matter that is of interest and that we will look at" (Cox, 2020b). Thus, in view of the report's green undertones, it is not unlikely that GTLTROs will be implemented in upcoming accommodative monetary policy interventions.

Interest in GTLTROs is also due to targeted longer-term refinancing operations (TLTROs) having proven to be a powerful instrument in boosting lending and easing banks' liquidity constraints (Laine, 2021; Andreeva & García-Posada, 2020; Sugo & Vergote, 2020). This has sparked the motivation of this thesis to explore whether GTLTROs could be equally effective and at the same time contribute to addressing the 'green investment gap' (IPCC, 2018).

With this intention, I carry out an analysis of GTLTROs' mode of action and an assessment of their expected implications with regards to three dimensions: lending, financial stability and market effects. With this type of impact assessment, I fill in a blank prevailing in the current green monetary policy literature: while proposals on green instruments are plentiful, analysis and impact assessments have remained sparse

[1] The term 'bank' is used to refer in a less technical way to 'monetary financial institutes' (MFI) that is institutes defined by their function to take deposits, grant credit and make investments.

up to this point (NGFS, 2021). The methodological approach guiding my assessment combines empirical evidence with economic theory inspired reasoning. This approach lends itself to cope with one main challenge of this paper, namely to evaluate under which conditions evidence that has been collected for TLTROs can be extrapolated to GTLTROs. Since this paper is written with the general thrust of economics, questions with a political feasibility, legal or practical implementation focus are only mentioned in passing.

My analysis is structured in the following way. Following this introduction, I will motivate the proposal of GTLTROs and portray the literature relevant for my investigations in Chapter 2. The third chapter will elaborate on the concept of GTLTROs. Chapters 4, 5 and 6 will assess the impact of GTLTROs along with the dimensions of lending, financial stability and market effects respectively. In Chapter 7 I conclude and propose possible focal points for further research.

2. The Case for Green Monetary Policy

Why green monetary policy? And why set up green refinancing operations? I will sketch an answer to these questions and motivate the proposal of GTLTROs in the first section of this chapter. Subsequently, in the second section, I present the literature relevant to my analysis.

2.1 The Role of Climate-related Financial Risks

The turn to green monetary policy goes back to what has been first described by Mark Carney as "climate-related financial risks" (CRFRs) (Carney, 2015). CRFRs can be regarded as one gateway through which climate change enters financial markets and central banks' operating environments. CRFRs refer to risks that manifest in banks', central banks' or more generally any investor's balance sheet related to environmental transition policies (so-called 'transition risks') and/or climatic disturbances that impair economic activity ('physical risks') (Bolton et al., 2020; NGFS, 2021; Dafermos et al., 2018). An example of when CRFRs could materialize would be a government's decision for a coal phase-out which would render coal plants unviable. Consequently, firms in the coal sector that have not aligned their business model to transition policies, are forced to shut down production. In such a scenario, investors would withdraw from the affected firms which in turn leads to massive asset re-valuations (Bolton et al., 2020). Banks still invested in respective firms would incur losses and spread instability across the financial sector (Monnin, 2018). The reason why this instability could unfold in the first place is that, as I stipulated, the risk of a transition policy being implemented has not been taken into account either by investors or the plant's management. The result of this biased risk assessment is that businesses are valued higher than

would be adequate in view of their CRFR exposure. If now CRFRs materialize contrary to agents' risk assessment, firms' 'actual' market value is revealed unmasking some firms as unprofitable. This triggers the above-sketched divestment reactions.

Given these potential market disruptures, green monetary policy scholars argue that CRFRs pose a threat to the ECB's fulfilment of its mandate. This tenor is shared by Isabel Schnabel, a member of the ECB's executive board. As Schnabel stresses, CRFRs "affect price stability and the transmission of monetary policy to the real economy…" (Schnabel, 2021a). In this way, CRFRs might jeopardize the ECB's ability to reach its primary mandate of preserving price stability in the Eurozone. Price stability is defined as targeting a medium-term inflation rate of 2 % (ECB, 2021c). Green monetary policy scholars have argued that CRFRs might affect the ECB's mandate beyond price stability. More concretely, they argued that CRFRs could impede the accomplishment of the financial stability objective linked to the ECB's role as a supervisory authority and of the secondary mandate of contributing to the European Union's (EU) sustainability-led general economic policy. Therefore, it has been argued that central banks should factor in CRFRs in their monetary policy operations[2]. At this point, GTLTROs have been proposed as a monetary policy instrument that involves pricing in CRFRs through fostering green lending:

> *Because most banks do too little to incorporate environmental criteria into their lending decisions, they may lend in ways that conflict with the ECB's monetary and financial stability objectives, as well as the EU's environmental objectives…. A green TLTRO can counteract such market practices, and thereby contribute to the ECB's primary objective of price stability, its secondary objective for supporting the economic policy objectives of the EU and its financial stability objective.*
>
> Jens van't Klooster and Rens van Tilburg in (Cox, 2020b)

To sum up, as the quote by Jens van't Klooster and Rens van Tilburg (2020) substantiates, the argument for GTLTROs is made because they are assumed to do better in supporting the ECB's remits than conventional refinancing operations. The assumption underlying this claim, which I motivated in this chapter, is that CRFR containment is necessary for mandate compliance. In the subsequent section, I present the literature to which I will recur throughout this paper.

[2]As this rationale shows, emission abatement is not stated as a first-order reason to introduce a green monetary policy. Evaluating green monetary policy with respect to its capacity to abate greenhouse gas (GHG) emissions, though certainly a result of containing CRFRs, therefore misses the point.

2.2 Literature Review

Three strands of literature are relevant for my endeavours. Firstly, the green monetary policy literature has examined the effect channels through which climate change affects monetary policy (Monnin, 2018), pioneered proposals to build in climate impacts in macroeconomic models (NGFS, 2021; Bolton et al., 2020; Dafermos et al., 2018) and portrayed a plethora of green monetary policy instruments such as green micro and macro-prudential regulation, green collateral policies, green quantitative easing (QE) and green credit allocation (Dikau et al., 2020; Dikau & Volz, 2021; Dafermos et al., 2021; Schoenmaker, 2021; NGFS, 2021, for an overview).

Since direct evidence on green refinancing operations is mostly out of context (Barkawi & Monnin, 2015; Barmes & Livingstone, 2021), the second strand of literature which I draw upon are empirical investigations of TLTROs. Most studies on TLTROs have examined the effects of the ECB's TLTRO I and II series with a focus on their impact on lending (Laine, 2021; Balfoussia & Gibson, 2016), their side effects on funding markets (Andreeva & García-Posada, 2020; Bats & Hudepohl, 2019) and the characteristics of participating banks (Sugo & Vergote, 2020). This literature is crucial to assess how GTLTROs may change funding conditions for banks and which factors play a role in enhancing or inhibiting this (on the latter see also Scharfstein & Sundera, 2016; Drechsler et al., 2017; Benetton & Fantino, 2020).

Thirdly, contributions of the green (also 'sustainable') finance literature inform my paper. Green finance scholars have investigated the investment and funding of banks to green determinations (Harrison & Muething, 2021; Harrison et al., 2020; Ehlers & Packer, 2017). Most relevantly, they pointed at differences in the process of lending when credit takers are 'green' as opposed to 'conventional' (Campiglio, 2016; Migliorelli & Dessertine, 2019).

This paper mainly contributes to the first strand of literature by pointing out which parts of the more established literature corpus on TLTROs and green finance matter for debates in green monetary policy. While impact assessments are a common format of ex-ante evaluation of policy proposals (see e.g. Renne (2012) for the case of TLTROs), to the best of the author's knowledge, this is the first paper to conduct a comprehensive impact assessment for GTLTROs. To lay the foundations for my investigation, I will introduce the concept of GTLTROs in the next chapter.

3. The Concept of GTLTROs

To conceptualize GTLTROs, I draw on contributions by van't Klooster and van Tilburg (2020), the Network for Greening the Financial System (NGFS, 2021) and Dikau et al. (2020). I will characterise the concept of GTLTROs in this chapter's first part and turn to details on its interest rate scheme in the second part.

3.1 Baseline Characteristics

GTLTROs are assumed to maintain essential features of TLTROs. TLTROs are refinancing operations with a maturity of 3 to 4 years that were set up to provide longer-term finance to banks (ECB, 2021d). A pivotal design feature of refinancing operations refers to the question of how borrowing rates are set. In TLTROs, banks that increased lending to the real sector could borrow TLTRO funds at concessional rates. Here, GTLTROs differ. Rather than a bank's lending performance per se, a bank's 'green lending performance' is taken to determine which borrowing rate the bank is charged (details follow in the next section). To define what qualifies as 'green lending', van't Klooster and van Tilburg (2020) plead for falling back on the EU Taxonomy[3] (European Commission, 2021). Hence, 'green lending' would be synonymous with 'Taxonomy-compliant lending'[4]. When distinguishing between 'green' and 'brown' activities in the course of this analysis, I take over this definition. Green lending in turn is likely low-CRFR lending: first, transition risks are likely lower since the activities of green borrowers align with expected EU environmental policies. Second, green borrowers might be less exposed to physical risks as they are better adapted to expected climatic developments.

Elaborating on and extending van't Klooster and van Tilburg's (2020) proposal, GTLTROs could also include a green collateral modification. Two options are conceivable. First, the ECB could make participation conditional on the CRFR-properties of collateral deposited by counterparties. Second, haircuts based on the CRFRs (henceforth 'CRFR-haircuts') properties of an asset could be applied. Haircuts are discounts that the Eurosystem applies to securities pledged by banks to approximate costs of resale and value fluctuations. Both adjustments will be discussed in detail in Chapter 5.

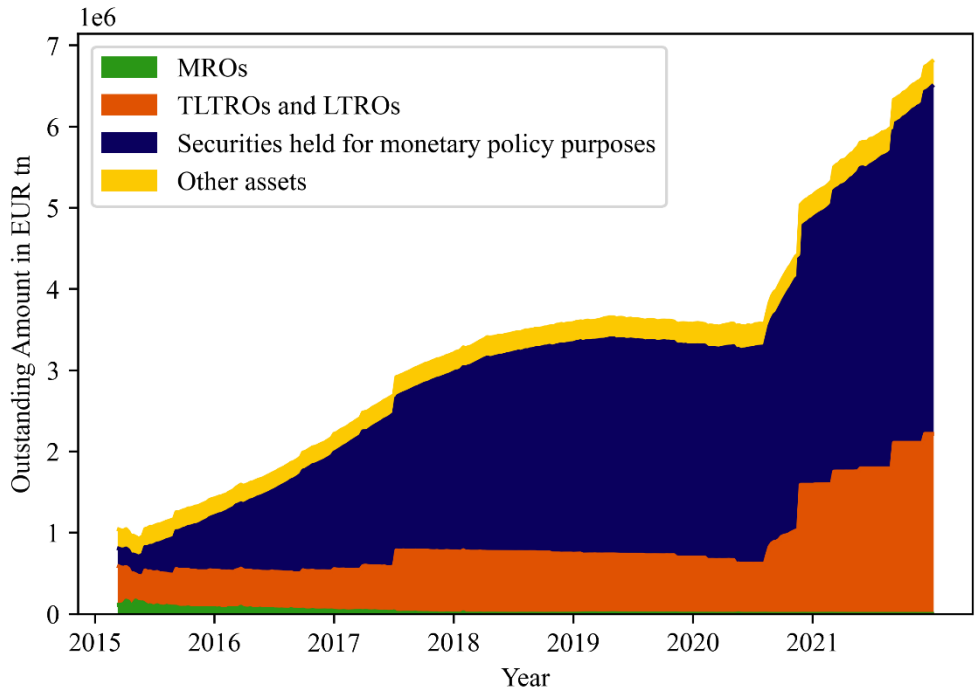
As do TLTROs, GTLTROs fit in with the spectrum of unconventional monetary policies (NGFS, 2021). These policies have been at the centre of the ECB's attempt to reinforce its accommodative stance at the

3 In terms of the vividly held discussion on central banks' mandate (see Section 6.2), linking the sustainability requirement of green monetary policies to the EU Taxonomy has the clear advantage of basing the ECB's decision on what can be considered "green" on a classification developed by a democratic corpus (the EU parliament).

4 Whether an economic activity is Taxonomy-compliant is defined by assessing its effects with respect to the criteria 'Adaption', 'Mitigation', 'Biodiversity' and 'Circular Economy' (KPMG, 2020).

effective lower bound (Mouabbi & Sahuc, 2019). Figure 1 shows the outstanding amounts of assets held for unconventional policies. In relation to other unconventional policies, TLTROs conjointly with other longer-term refinancing operations (LTROs) added up to EUR 2,216 billion (bn) in 2021 or 32.57% of the outstanding amount. This suggests that GTLTROs would make up a considerable part of unconventional policies under the assumption that past dosage is anything to go by.

Figure 1: ECB Balance Sheet Changes due to Unconventional Policies



Notes: 'Securities held for monetary policy purposes' refer to securities held as part of the asset purchase programme

Source: ECB (2021a), own diagram

Unconventional policies like QE directly ease corporate or government financing conditions (Fiedler et al., 2019). In contrast to that, credit easing measures like GTLTROs indirectly improve firms' financing conditions. This should allow banks to offer loans at more favourable conditions and thereby increase corporate loan demand.

Noteworthy, incrementing lending is not the sole aim of GTLTROs. Turning to TLTROs, an important function of the operations has been to equip banks with liquidity. In this way, TLTROs have been used as a tool to prevent or alleviate crises and strengthen financial stability (NGFS, 2021). To which degree GTLTROs fulfil this function as well will be analysed in Chapter 5. Preliminary to my latter engagement with financial stability, I follow van't Klooster and van Tilburg with respect to an assumption that marks out the focus of the financial stability analysis: I assume that LTROs continue to exist while GTLTROs would replace TLTROs, as opposed to being juxtaposed to TLTROs. Having said this, my analysis investigates GTLTROs under the assumption that conventional LTROs as well as the ultra-short-term liquidity

via weekly auctions would be still accessible irrespective of a bank's green performance. By stipulating the availability of such conventional liquidity facilities, the most extreme case of a central bank withholding liquidity in financial stress scenarios for CRFRs considerations is ruled out. Investigation of the interplay of green and conventional liquidity facilities is a question for another paper.

Since the works I have so far consulted to characterise GTLTROs fail to specify a scheme to determine interest rates, I will next elaborate on a possible surrogate. Definition of such a scheme is necessary to have a point of reference for the impact assessment in subsequent chapters.

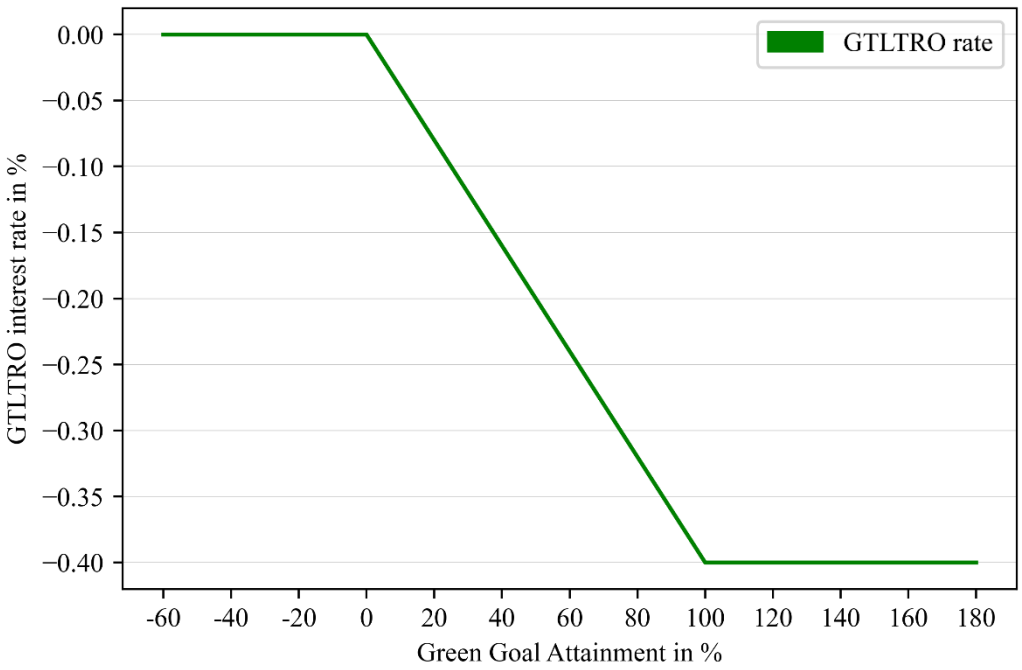
3.2 Determination of Interest Rates

The interest rate scheme in GTLTROs defines how a bank's green lending performance translates into the borrowing rates it is charged on GTLTRO credit. Defining an interest rate scheme that is best suited to promote the aims of GTLTROs and provides optimal incentives is an intricate issue. An extensive review of possible options regarding their optimality is beyond the scope of this paper. For instance, to illustrate the complexity involved here, an interest rate scheme has to specify how 'green lending performance' is measured. Here, numerous measuring benchmarks exist. To name a few: a bank's absolute increase of green loans, a bank's relative increase of green loans or a multi-factor model which takes various assessment points as inputs. Another challenge is to weigh the aim of (a.) stimulation of green lending against (b.) the financial stability supporting function of GTLTROs in such a scheme. For instance, benchmarks that are easy to fulfil would imply that banks receive favourable GTLTRO rates even if they only moderately improved on green lending. This would be conducive to financial stability but not the best choice to foster green lending.

In view of the extensive scope of these questions, instead of pinning down a suitable target figure, I assume a 'generalized version' of an interest rate scheme where I leave unspecified which exact target figure is used to measure a bank's green lending performance. Instead, I assume that banks receive GTLTRO rates based on their 'green goal attainment in per cent'. 'Green goal attainment' thus functions as a placeholder for a target figure to be specified by policy-makers. For instance, in TLTRO II, goal attainment was specified as the 'percentage lending increase relative to a pre-period'. This generalized version allows me to investigate several features of GTLTROs in subsequent parts of the analysis in the absence of a specified interest rate scheme. Below, in Figure 2, I have plotted this generalized interest rate scheme. I adopted the range of interest rates used in TLTRO II: banks with a goal attainment of 0 % or below were granted a rate of 0.0% corresponding to the rate on the main refinancing operations (MRO) at that time; banks with a goal attainment of equal or more than 100% received a rate of minus 0.4% which equalled the rate on the deposit facility (DF) (ECB, 2021d).

Goal attainment levels between 0 and 100% were translated linearly into decreasing GTLTRO rates.

Figure 2: GTLTRO Interest Rate Scheme



Source: ECB (2021) and own modifications, own diagram

In this chapter, I defined GTLTROs as central bank credit operations that involve concessional lending depending on a counterparty's green lending performance. In this way, GTLTROs pursue two aims: firstly, they aim at promoting green lending. Secondly, given the above-made assumption that GTLTROs would substitute TLTROs, they should support financial stability. Assuming that GTLTROs would follow the design as outlined in this chapter, I will subsequently analyse their impact starting with the effect on lending in the next chapter.

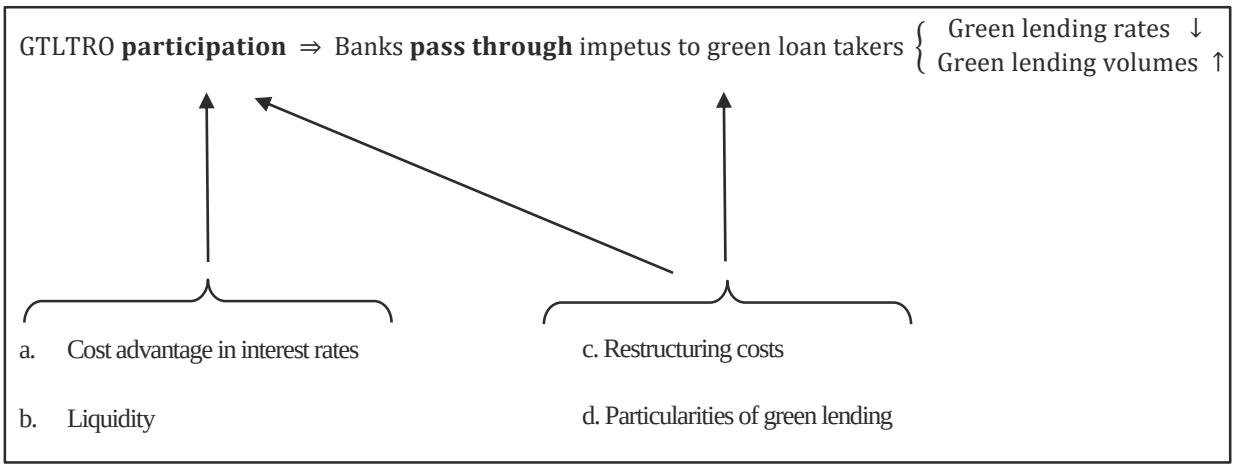
4. The Impact of GTLTROs on Lending

Various studies have substantiated that TLTROs had a positive effect on lending (Afonso & Sousa-Leite, 2020; Andreeva & García-Posada, 2020; Bats & Hudepohl, 2019; Laine, 2021). This makes the study of similar effects for GTLTROs a natural point of focus. I begin with sketching the theoretical underpinnings of the effect on lending to be able to check in a second step whether the effect on lending is at work for GTLTROs.

Theoretically, the 'effect on lending' refers to the increase in granting of credit to the green real sector that could be set free as banks participate in GTLTROs (Andreeva & García-Posada (2020) for the conventional effect on lending). As pointed out, GTLTROs imply lower borrowing rates for banks that increase lending to green firms. Thereby, the ECB creates an incentive for banks to pass through lower lending rates to green businesses. Banks do so to reflect that their funding costs are lower when serving green clients. In this way, transmission is expected to be targeted to the green financial and corporate segment only.

Following an approach used for a pre-implementation assessment of TLTROs by Renne (2014) the effect on lending can be dissected into two causal links: participation and pass through. Participation regards the question of whether banks will participate in GTLTROs. Pass-through is about whether banks transmit concessional GTLTRO rates to green loan takers. As visualized below in Figure 3, if pass-through takes place, lending rates for green loan takers decline and the total amount of green loans increases.

Figure 3: Effect on Lending



Source: Own diagram

Partly following the literature on TLTROs, partly building on the green finance literature I stipulate that factors (a.) to (d.) are the key drivers of participation and factors (c.) and (d.) of pass-through, as is depicted in the chain of effects above (Migliorelli & Dessertine, 2019; Andreeva & García-Posada, 2020; Laine,

2021; Sugo & Vergote, 2020).

For the remainder of this analysis, I hypothesize that the effect on lending works as I have outlined here. Assuming this theoretical conceptualization of the effect on lending, I will subsequently investigate if and in which way this effect likely unfolds for GTLTRO. To do so, I investigate the impact of factors (a.), (c.) and (d.) on the effect on lending. The factor (b.), 'liquidity', i.e. the ability of GTLTROs to provide banks with liquidity, will be elaborated in Chapter 5 when turning to GTLTROs' financial stability impact. In this way, I try to do justice to the fact that liquidity does not only affect lending as a motive for participation but also has financial stability ramifications. To sharpen the focus of this analysis, the investigation on lending will be restricted to corporate lending, bracketing lending to the private sector. I begin with factor (a.), the cost advantage in interest rates.

4.1 Cost Advantage in Interest Rates

For banks' decision whether to participate in GTLTROs, not the GTLTRO rate per se but its cost advantage compared to market-based funding alternatives is crucial (Sugo & Vergote, 2020, p. 13). Therefore, this section aims to examine how GTLTROs compare to other green funding options in terms of interest costs.

Which funding options apart from GTLTRO could a bank source to fund green projects? Transferring the approach of Sugo and Vergote (2020) to the green case, I assume that green covered bonds can be taken as a substitutive funding means. Green covered bonds are covered bonds the proceeds of which are earmarked for green purposes (Climate Bonds Initiative, 2017). They exhibit similar security features as covered bonds because they are backed by a separate cover pool and the receivables underlying them stay on the balance sheet of the issuer (Kenton, 2020). Thus, if taking bonds of the same maturity, green covered bonds qualify as a substitute for GTLTROs.

To compare interest rate costs of GTLTROs to green covered bonds I build on an approach described in Sugo and Vergote (2020) based on Will and von Koss (2016). Following this approach, I assume a narrow understanding of 'cost advantage' as 'cost advantage in terms of interest rates'. Thus, the cost advantageous funding source is the source that is obtainable at the lowest interest rates.

To illustrate the cost advantage numerically, I assume that a bank wants to raise EUR 1 million (m) of funds. Available funding options are GTLTROs and green covered bonds. When funding via GTLTROs, I assume that a medium-sized haircut of 10.4% applies to the collateral pledged by the bank. Building on the generalized interest rate scheme presented in Section 3.2, I distinguish between two scenarios: a maximum rate of 0.0%, corresponding to a green goal attainment of 0% or below and a lower rate of minus

0.4% which is granted to counterparties with a green goal attainment of 100% or more. To compute the costs of green covered bonds, I used bonds issued between 2017 and 2021.

Accruing interest costs and interest income to maturity for an amount of EUR 1 m are stated in Table 1.

Table 1: Interest Costs for Banks to Fund EUR 1 m

Funding Option	Scenario I (0.0 %)	Scenario II (-0.4 %)
GTLTROs (EUR)	-453.66	3130.34
Green Covered Bonds (EUR)	-10209.50	-10209.50
GTLTROs robust (EUR)	-208.41	3375.59
Yield*(%)	-0.028	-0.038
Cost Advantage (%)	0.966	1.321

Sources: Refinitiv Eikon and own calculations

Positive amounts mean that a bank receives (positive) interest income; negative amounts are accruing interest costs. The first row presents interest costs (income) for borrowing EUR 1 m of GTLTRO funds. The second row shows interest costs accruing for a bank when funding EUR 1 m with green covered bank bonds in Eurozone countries. In both scenarios, costs for GTLTROs are lower than for green covered bonds, with banks facing lower costs at a GTLTRO rate of 0.0% (EUR - 453.66, compared to EUR - 10209.5) or even receiving positive payments at a rate of minus 0.4% (EUR - 3130.34 compared to EUR - 10209.5) when using GTLTROs. A possible concern regarding this estimate is the small sample size of green senior uncovered bonds which might lead to biased estimates. This class of bonds was used to calculate GTLTRO costs (more details are given in the appendix). As a robustness check, I have let the restriction of 'senior class bonds' fall in row three and included 'non-senior' bonds. In both scenarios, costs for 'GTLTROs robust' are even more beneficial than in the original GTLTRO calculation (EUR - 208.41 compared to EUR - 3375.59 in Scenario I). This suggests that the small sample has not upwardly biased the results.

Next, I reported the yields for which costs of green bonds and GTLTROs would be equal (Yield*). Since yields are standardly denoted as annual rates, I have adjusted Yield* to fit with the GTLTRO maturity of 4 years. This exercise indicates that green covered bond yields would have to be in the ballpark of current sovereign bond yields of high-rated states (e.g. the French 5-year bond) to be equally attractive as GTLTROs (World Government Bonds, 2021). For policy-makers, Yield* could be utilized as a control

to adapt GTLTRO rates and keep them attractive if they are liable to be undercut by green covered bond yields. In the last row, I report the cost advantage in per cent (%) of GTLTROs relative to green covered bonds. A positive percentage value indicates a cost advantage of GTLTROs compared to green covered bonds. The cost advantage is computed as the ratio between the borrowing amount of EUR 1 m plus (minus) GTLTRO interest income (costs) and EUR 1 m minus green covered bond interest costs. The cost advantage accrues to 0.966% in Scenario I and 1.321% in Scenario II. This is slightly higher than the average cost advantage of 0.43% Sugo and Vergote (2020) got for TLTRO I and II compared to covered bonds in the period between 2014 and 2017.

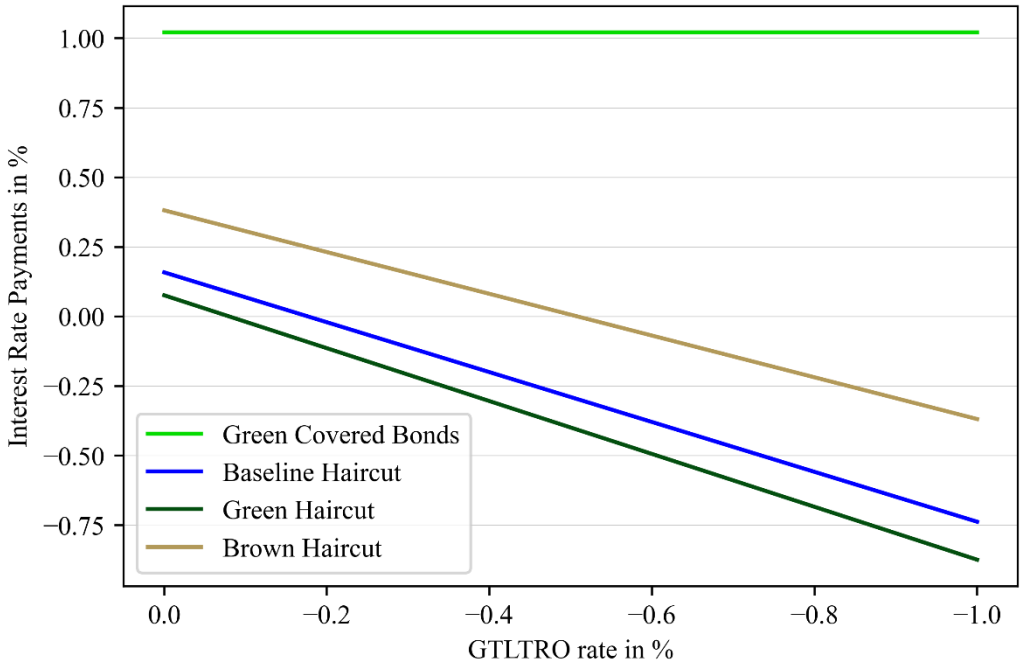
This estimate is of a very general nature as estimates are based on average Eurozone bond yields. Therefore, I will consider two parameters, namely haircuts and country location that might lead to a differently pronounced cost advantage across banks.

Starting with haircuts, CRFR-haircuts influence the costs a bank bears for participating in GTLTRO. As motivated in Section 3, CRFR-haircuts would be applied to an asset pledged as collateral in GTLTRO transactions (Schoenmaker, 2021): haircuts are lowered for green assets and incremented for brown assets respectively changing costs of participation. To illustrate the impact of haircuts on costs accruing for GTLTRO participation, I have plotted interest costs (income) of GTLTROs and green covered bonds in rates (y-axis) for different GTLTRO scenarios (x-axis) in Figure 4. The blue curve and the light green curve are the 'interest rate' equivalents of absolute values stated in rows one and two of Table 1: they depict accruing interest costs for GTLTRO and green covered bond funding respectively[5]. As in Table 1, I assume a 10.4% in GTLTROs. Due to the medium size of the haircut, I refer to this as the 'baseline case'. Different to Table 1, Figure 4 covers the whole spectrum of GTLTRO rates from 0.0% to minus 1%. Also, costs for hypothetical GTLTRO rates of minus 1% are mapped. This extension depicts the policy space through further interest rate cuts. In addition, I have plotted interest costs (income) in rates for different CRFR-haircuts. I distinguish between a 'green haircut' (6.4%, dark green line) for low-CRFR collateral and a 'brown haircut' (14.6%[6], brown line) for high-CRFR collateral respectively. In fact, in its 2021 strategy report, the ECB envisions haircuts to become CRFRs sensitive by 2023 similar to what I assume here (Lagarde, 2021a).

[5] For the sake of simplicity, I assumed that yields on green covered bonds are independent of GTLTRO rates, as is illustrated by the constant green covered bond curve. Funding externalities analysed in Chapter 6 question exactly this assumption pointing to possible changes in bond yields resulting from an increased supply of GTLTRO funds.

[6] Note that the percentage values denote the additional haircuts due to CRFRs, not the entire haircut.

Figure 4: Interest Costs of GTLTROs for Different Haircuts



Source: Refinitiv Eikon, own diagram

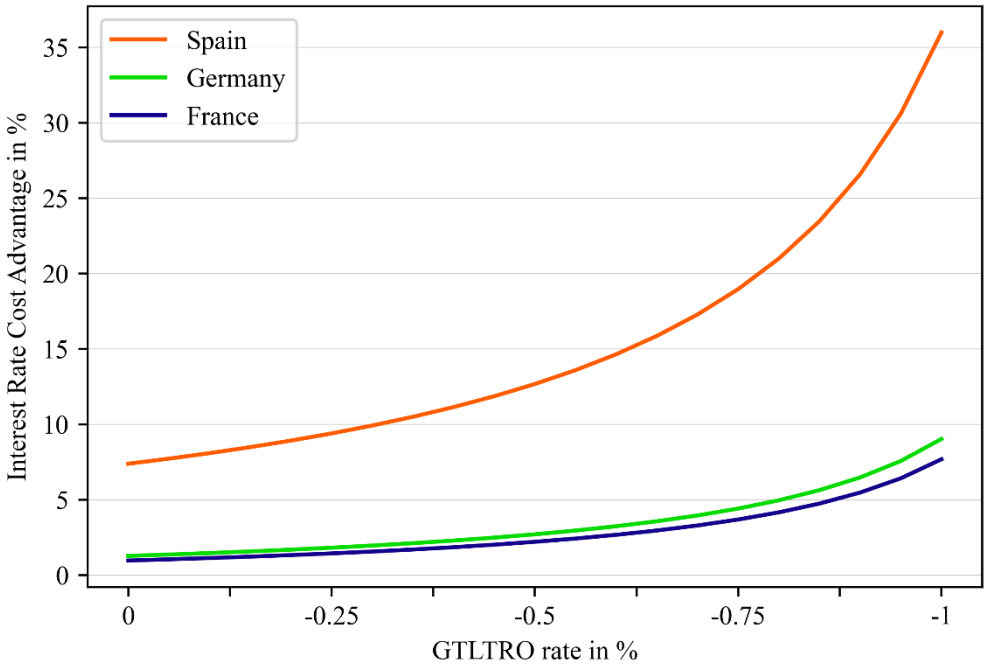
Looking at the cost advantage attributable to green (brown) haircuts, the absolute cost-benefit (burden) compared to the baseline case is more pronounced for higher GTLTRO rates. The relative cost-benefit (burden) of each haircut relative to the baseline case however decreases for higher GTLTRO rates. Thus, the relative savings due to pledging green collateral are higher for a bank that has not incremented lending and borrows GTLTROs at a rate of 0.0% compared to a bank that receives GTLTRO funds at the most favourable rate of minus 0.4%.

The overall picture however is that the effect of haircuts on cost advantage is of minor importance. For example, assuming the above case of a bank borrowing EUR 1 m, the bank receives net payments of EUR 1996.19 in the baseline case at a rate of minus 0.4% (see Table 1). A brown haircut, which implies 22.13% less favourable interest rates compared to the baseline case, would reduce net payments to EUR 1554.43; a loss that seems insufficient to change incentives significantly. It is also worth stressing that even in the case of a brown haircut GTLTROs, exhibit a clear cost advantage compared to green bonds. This seems to indicate that CRFR-haircuts alone, while potentially unravelling market effects as I investigate in Chapter 6, are unlikely to significantly affect cost advantage considerations.

Another parameter that might affect the cost advantage is a bank's country location. Given that green covered bond yields vary across countries, with yields being higher in low-rated countries such as the

PIIGS countries[7], the cost advantage might be more pronounced in these countries as banks can dodge the costs of high bond premia. To check this hypothesis, I plotted the cost advantage for Spain, Germany and France in Figure 5.

Figure 5: Cost Advantage of GTLTROs over Green Covered Bonds by Country



Source: Refinitiv Eikon, own diagram

Notably, the cost advantage is indeed most pronounced for PIIGS country Spain. For a GTLTRO rate of 0.0%, participation in GTLTROs is 2.29% cheaper, incrementing to 4% at a GTLTRO rate of minus 0.4% and skyrocketing to 35% for a hypothetical rate of minus 0.95%. These figures are considerably higher than for the remaining countries which can be considered high-rated for which the cost advantage ranges between 1 and 2.3% in the spectrum of 0.0% to minus 0.4%. This is in a similar ballpark as the cost advantage of the average estimates for the Eurozone in Table 1. This indicates that GTLTRO uptake might be higher in low-rated countries which have particularly strong cost incentives for uptake.

To conclude, this section has found that the GTLTROs would have a cost advantage compared to green covered bonds. Given the relevancy of the cost advantage as a motive for uptake in TLTROs (Sugo & Vergote, 2020), this points to positive prospects for participation in GTLTROs. This finding is subject to the restriction that as green finance mainstreams, green covered bond finance might be obtainable at more attractive conditions in the future than stipulated here. While the impact of CRFR-haircuts on costs has been found to be moderate, the influence of country location is considerable.

[7] This country grouping comprises Portugal, Ireland, Italy, Greek and Spain.

In the subsequent section, I scrutinize factor (c.), restructuring costs.

4.2 Restructuring Costs

Restructuring costs are costs that accrue for banks to recalibrate their portfolio to optimize it for the change in financing caused by GTLTROs. More precisely, banks' funding and lending strategy might no longer be optimal since GTLTROs change the set of funding sources by adding a new funding option. Therefore, the amount of restructuring costs that a bank anticipates accruing might have an influence on both, whether it participates in GTLTROs and the mode of pass-through.

Worth emphasizing, restructuring does not only refer to changing the mix of funding options. If banks do this is exactly the question of funding cost advantage discussed in the previous section. It may also involve changes in the asset side of the balance sheet. As GTLTRO terms depend on banks' lending patterns, an adaptation of the lending pattern is a natural starting point for restructuring. However, banks might face different incentives to engage in restructuring. For some banks, it might be profitable to include more green loans to obtain lower GTLTRO rates. For others, it could be optimal to avoid the costs related to participation in GTLTROs and stick with conventional funding sources rather than take up GTLTROs. Banks' decision - whether they prefer changing their lending pattern to profit from low GTLTRO rates or stick with current credit takers and source conventional funding sources - can be formalized in the following way:

Participation Condition:

$$U_{GTLTRO\ Participation}(\overset{-}{R}) > U_{No\ Participation}(R) \qquad (1)$$

Determinants of Restructuring Costs:

$$R = R(\overset{-}{DC}, \overset{+}{G}, \overset{+}{CA}) \qquad (2)$$

The participation condition describes in a simplified way the calculation that banks face when they consider participation in GTLTROs. In Equation (1), the case of a bank that fares better participating, reflected by a higher utility, is shown. Signs above the variables reflect how variables impact the functional value. Thus, the utility associated with (non-)participation is a negative function of restructuring costs *R*. Equation (2) describes the factors which in turn determine restructuring costs. Restructuring costs are higher if disclosure costs (*DC)* i.e. costs that banks face for reporting and monitoring the 'greenness' of their lending are higher. Restructuring costs are lower if a bank exhibits a larger green focus (*G*) or if it has a larger cost advantage (*CA)* e.g. because it is based in a PIIGS country.

Certainly, these factors should not be taken to be an exhaustive set of determinants but rather constitute an approximation.

Assuming that this calculus plays a role in banks' decision to take up GTLTRO funds, a probable implication is that banks with lower restructuring costs are more likely to participate in GTLTROs. Conversely, banks with high restructuring costs are better off sticking to their portfolio and sourcing other refinancing options. Restructuring costs are also important for pass-through. Those banks which participate in GTLTROs as for them Equation (1) is satisfied might have an incentive to pass through funds in a way such that their costs are minimal. Admittedly, other maxims than cost minimization such as maximizing return could guide banks' pass-through strategy. Yet, if one assumed that cost minimization is decisive, banks would favour clients whose sustainability assessment would incur lowest restructuring costs. This would result in an allocation where GTLTRO funds are demanded and green credit is boosted by those banks which can do so at lowest restructuring costs. Also, banks pass through GTLTRO funds to those firms for which green lending costs are lowest. Although this result might sound desirable in the first place, it probably is not under further scrutiny. This is because investing where restructuring is cheapest is not equivalent to investing where mitigating greenhouse gas (GHG) emissions is cheapest.

To illustrate on this point, a bank with a lending focus on wind energy will have low restructuring costs since *DC* is low (wind energy is per definition Taxonomy-compliant and does not require extensive screening on the bank's side) and G is high (such that the bank is spared the costs of setting up new green investment relationships) (van't Klooster & van Tilburg, 2020). Also, one could assume that *CA* is high as the bank is headquartered in Spain. Such a bank will likely prefer participation. Also, this bank will continue to direct its credit to wind energy partners which is the lowest cost option. Consequently, this bank as well as its wind energy clients will have favourable funding conditions. In particular, their funding conditions will be better than those of companies with similarly good sustainability characteristics.

In view of these theoretical considerations, the question arises whether and to what extent differences in terms of the determining variables *DC*, *G* and *CA*, as I have hypothesized here, actually exist. Since I have already covered *CA* in the previous section and *G*, as bank-level characteristic is notoriously difficult to measure, I will focus on *DC*. Regarding DC, Table 2 shows the percentage of companies by sector that have disclosed sustainability-related information about their business. Progress in disclosure varies among sectors with 'Energy' and 'Materials and Buildings' leading the field. These more progressed sectors might profit to an above-average extent from GTLTROs because banks might prefer to lend to industries with more established and reliable disclosure procedures. This is true also for per definition Taxonomy-compliant sectors, as pointed out above.

While from an economic theory perspective the distorting effect of GTLTROs via restructuring costs is worth pointing out, in practical terms a better grid position of the sectors most affected by the transition to

Table 2: Share of Disclosed Companies by Industry

Industry	Dislosure (%)
Energy	40
Materials and Buildings	30
Insurance Companies	27
Agriculture and Forest Products	25
Banks	23
Transportation	23
Consumer Goods	18
Technology and Media	13

Source: TCFD (2020), own diagram

a net-zero economy might not be troublesome. Also, the distortion could be relatively small in scale compared with the opportunity costs involved in not using GTLTROs.

One way to level differences in restructuring costs proposed by van't Klooster and van Tilburg (2020) consists in adding SME or sector-wise correction factors to equalize differences *DC*. In addition to that, country benchmarks could help to account for cross-country heterogeneities in *CA* due to differences in costs for substitutes. I consider factor (d.), particularities of green lending, in the next section.

4.3 Particularities of Green Lending

The hypothesis that motivates this chapter is that banks' lending decisions might differ if they are positioned vis-à-vis green instead of conventional borrowers. This is what I try to grasp with 'particularities of green lending'. As such particularities might change banks' lending behaviour this could then again change the effectiveness of GTLTROs. Therefore, I will explore which green finance particularities exist and how they might impact the effect on lending of GTLTROs.

One cluster of theoretical findings on green lending goes back to Campiglio (2016) and Punzi (2018). They found that banks tend to severely curtail lending to green firms or projects (Campiglio, 2016; Punzi 2018). According to the authors, the reason for this is a "green credit rationing". Similar to conventional credit rationing, green credit rationing refers to a supply gap of green credit. This supply gap is due to

informational asymmetries specific to green lending. For instance, green enterprises are overproportionally younger enterprises. This entails that investors lack experience values of the performance of enterprises which engenders hidden characteristics. As consequence, banks supply less credit than is demanded (and would be socially optimal) with the result that markets clear at the rationing equilibrium leaving willing credit takers unserved (Jaffee & Stiglitz, 1990). For conventional credit markets, there is a still ongoing debate about whether low levels of credit in the period after the 2008 Global financial crisis (GFC) are a symptom of credit rationing or rather reflect weak credit demand. In green markets, the case seems to be clearer as various particularities of green lending have been found to limit credit supply. Hence, the suspicion is that low levels of green credit (Marois, 2017) are a supply-side issue and indeed a symptom of a green credit rationing. The following particularities of green lending have been cited by the literature as adversely affecting green lending: (i.) higher upfront costs of green investments, (ii.) longer terms and (iii.) uncertainty regarding political, technological and financial conditions.

Concerning the first impediment Nelson and Shrimali (2014) estimate that upfront capital costs amount to 84 to 93% of the overall costs of investment for wind, solar, and hydro energy which compares to 66 to 69% for coal or 24 to 37% for gas (Nelson & Shrimali, 2014). In addition to this, usually, green borrowers do not dispose of high-value collateral in contrast to e.g. heavy industry which can fall back on mortgages.

Longer terms (ii.) typical for green investments, conflict with liquidity requirements which have gotten tighter in the aftermath of the GFC (van't Klooster & van Tilburg, 2020). Liquidity regulations require banks to have a sufficient amount of liquidity at their disposal. Long-term investments counteract this since they tie up capital for longer periods. The third particularity, high uncertainty (iii.), erodes planning security. Also, uncertainty requires banks to mobilize more resources to acquire information about firms and mitigate informational deficits. For instance, such search costs could accrue as banks research the prospects of certain technologies used by firms.

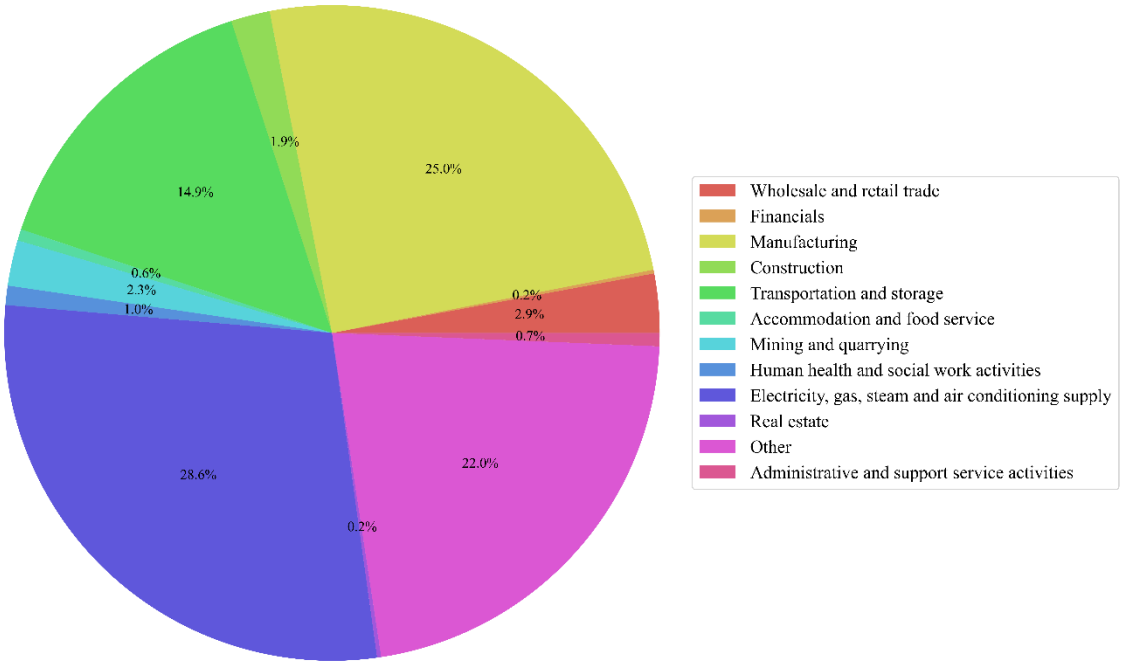
Beyond these structural impediments (i.-iii.), the macroeconomic situation could also be a factor compressing green lending. Characterising credit markets as still seized by the aftershocks of the GFC and the 2010 European debt crisis, Benetton and Fantino (2020) diagnose cautiousness as a basic constant of banks' conduct. Especially, the authors find evidence for a 'flight to quality': banks attempt "to allocate their means towards the smaller and ex-ante safer firms" (Benetton & Fantino, 2018, p. 3)[8]. This suggests that, next to banks' general reluctance towards lending, if they lend, they prefer safer firms. This disposition in the banking sector could overproportionally harm green lending as green firms are generally considered

[8] According to Benetton and Fantino (2020), the effect of TLTROs on lending was more pronounced for smaller firms because they are more dependent on loans to obtain finance.

riskier by investors due to e.g. uncertainty, as stressed above. Thus, banks' safety preference might prompt banks to evade green lending and dissuade them from participation in GTLTRO.

Next to these theoretical findings, statistics on the 'green orientation' of the actual granting of credit might be instructive. This is because if non-green lending is highly pronounced and widespread, it will likely be more difficult for GTLTROs to move banks towards green lending. Looking at the breakdown of credit provision by NACE sector[9] (Figure 6), it can be noted that the three high-carbon sectors 'Manufacturing', 'Electricity, gas, steam and air conditioning supply' and 'Transportation and storage' together account for 68.5% of outstanding loans albeit only making up 24.4% of the EU's gross value added (GVA). GVA corrects GDP for taxes and subsidies and is thus more suitable to measure contribution to output by sector (Blanchard & Illing, 2014).

Figure 6: Outstanding Loans by Sector in 2021



Source: Refinitiv Eikon, own diagram

These three sectors account for 61.83 % of EU GHG emissions (Dafermos et al., 2021). In the three high-carbon sectors, 1% of GVA causes an equivalent of 95.41 m t CO_2. Compared to that, this value is on average 19 m t CO_2 or a fifth across the other sectors. While 68.43% of loans belong to the former high-carbon sector grouping, the remaining 31.57% can be assigned to the lower-carbon sectors. This indicates

[9] This is a statistical classification of industries used by the EU.

that relative to their proportion of GVA, carbon-intensive sectors are overproportionally equipped with credit. I take these statistics to indicate that current lending practices are inclined towards high-carbon sectors which likely impedes the effect on lending. Evidence by de Haas and Popov (2019) substantiates these findings on a more general level. As their study covering 137 countries concludes, bank-based economies are worse at providing green finance compared to economies where market-based finance is dominant (de Haas & Popov, 2019).

To sum up, particularities of green lending are likely to have a compressive impact on both participation and pass-through. The current inclination of the green loan market towards high-carbon industries likely adds inertia making it difficult for GTLTROs to move banks away from high-carbon industries and towards green lending. Given that around two-thirds of finance in Europe is provided by banks, winning them for green investment is crucial to achieving large-scale effectiveness (Bloomberg, 2015). Also, bank lending is better apt to include SMEs and small entities.

In summary of the entire examination of the effect on lending, GTLTROs offer an attractive cost of 0.996-1.321% which has been argued to be pivotal for large-scale participation. To counter heterogeneity in restructuring costs which I identified as possibly distorting uptake, GTLTROs should include correction factors. Several impairments, among those unfavourable investment properties of green projects, continuing bank cautiousness and closer ties of banks to high-carbon industries, pose challenges for green lending. This might hinder pass-through in GTLTROs. Given these impairments, I conclude that GTLTROs seem to be a highly indicated policy that addresses the disincentives underlying green credit rationing. To allow for a fuller picture of the impact of GTLTROs, I will investigate financial stability implications in the next chapter.

5. The Impact of GTLTROs on Financial Stability

According to Sugo and Vergote (2020), banks have ranked liquidity as a top reason for recourse to TLTROs (Sugo & Vergote, 2020). This finding stresses that apart from fostering lending, TLTROs importantly contributed to corroborating financial stability. This chapter will focus on the question of whether GTLTROs would support financial stability in a similar way.

As I remarked in Chapter 3, the financial stability effects of GTLTRO partly depend on the availability of conventional liquidity facilities and the relative weight given to financial stability versus green lending in the design of a GTLTRO interest rate scheme. For reasons explained in that chapter and given the limited scope of this paper, I bracket the evaluation of these parameters. Rather, the focus will be on how a green collateral modification would affect financial stability.

A green collateral modification built into GTLTROs could take the form of assessing and pricing the collateral counterparties deposit at the ECB to obtain GTLTRO means with respect to their CRFRs characteristics. Discussion of such a modification is of topical interest given the ECB's recent announcement to "consider relevant climate change risks when reviewing the valuation and risk control frameworks for assets mobilised as collateral" and to "introduce disclosure requirements for private-sector assets as a new eligibility criterion or as a basis for a differentiated treatment for collateral and asset purchases" (ECB, 2021b). Green collateral modifications could have a restrictive or expansionary design. I start by outlining restrictive collateral modifications.

5.1 Restrictive Collateral Modifications

In this section, I will review two restrictive green collateral modifications: CRFR-haircuts and a green eligibility restriction. A green eligibility restriction implies that the central bank accepts green securities only in GTLTRO repo transactions.

A first concern is that both measures could exacerbate access to GTLTROs for those banks which predominantly dispose of brown securities (henceforth 'brown banks'). More concretely, GTLTROs might not be as useful for liquidity conversion as were TLTROs. In TLTROs, banks converted liquidity by pledging illiquid assets as collateral and in return receiving TLTRO means. TLTRO means qualify as high-quality liquid assets (HQLAs)[10]. Therefore, banks could use TLTRO funds to improve their liquidity ratios and to abide by liquidity regulations, most importantly Basel III (BIS, 2010). Consistent with this, banks' uptake in TLTROs was higher if they fell short of HQLAs suggesting that liquidity conversion was a key driver of uptake (Sugo & Vergote, 2020).

GTLTROs would make it more preferable (in the case of CRFR-haircuts) or mandatory (in the case of a green eligibility restriction) for banks to pledge green collateral. Conversely, if banks pledge brown collateral, they incur higher costs. In case of a green eligibility restriction, banks that do not dispose of green collateral, have to acquire it at some cost. Apart from these increased expenditures for participation in GTLTROs, brown banks would also bear higher costs if they did not participate in GTLTROs as they face higher funding costs via the market as Section 4.1 concluded. Also, restrictive collateral modifications likely have the effect of devaluating brown collateral. If declared ineligible or penalized with higher haircuts, brown securities get less useful for banks. This is reflected in lower prices and lower liquidity of these bonds tantamount to higher funding costs for the issuers (Nyborg, 2017, p. 20; Cassola & Koulischer,

[10] HQLAs are characterised both by their liquidity and their high credit rating which make them useful to settle payments immediately (Grandia et al., 2019).

2019). Furthermore, as Lane et al.(2015) show, haircut regimes have an anchor point effect for market transactions between banks. Thus, banks likely imitate ECB haircuts in bilateral transactions amplifying the scope of the effect of collateral policies.

Synthesizing these effects, both restrictive collateral modifications would hamper the access for brown banks to ECB refinancing. Liquidity bottlenecks are becoming more likely. This constitutes a prima facie concern for financial stability. To assess how large in scale this effect would be, looking at the amount of brown non-HQLAs is pivotal. Focus on this class is indicated as non-HQLA have been the securities most harnessed as collateral in TLTRO transactions and brown assets are most affected by restrictive collateral modifications. Combining data on the share of non-HQLA pledged (65%) (Grandia et al., 2019) with data on the sector breakdown of eligible bonds (see Dafermos et al., 2021) I estimate that around 61 % of non-HQLAs qualify as brown[11]. Thus, if brown collateral becomes subject to a restrictive collateral modification this would affect a sizable volume of the market. Access to liquidity and funding likely is aggravated for a considerable number of agents.

Beyond financial stability, the devaluating impetus on asset values through restrictive collateral modifications potentially has a contractive effect on investments in non-green segments. At worst, the level of total investment might decline. As Raberto et al. (2019) show for the case of climate-differentiated capital requirements, policies with a restrictive impact on lending compress output and investments through lower lending volumes. Such effects could plausibly occur as a result of restrictive collateral modifications as they disfavour and possibly constrain conventional lending. Gripped by the general downward movement unleashed by this restrictive impetus, banks' primary endeavour is to consolidate their business situation. In this way, their appetite for riskier and presumedly lower-return green finance is reduced (Campiglio, 2016). Eventually, as less green lending means that the shift to a CRFR-resilient economy is deferred, restrictive collateral modifications could adversely affect financial stability through this channel. In summary, the primary effects of a restrictive collateral modifications are a reduced usefulness of GTLTROs for liquidity conversion and brown asset devaluation.

5.2 Expansionary Collateral Modifications

Turning to expansionary modifications, options are a green eligibility extension and CRFR-haircuts. A green eligibility extension would imply widening the spectrum of eligible collateral to include more green

[11] To arrive at this estimate I have made several assumptions: (i.) independence between the liquidity and the determination of a bond; (ii.) non-HQLAs, which are neither sovereign nor corporate bonds, exhibit the same sectorial composition as corporate bond market structure; (iii.) brown bonds are defined as bonds emitted by three high-carbon sectors in the EU economy (see Section 4.3).

collateral. While CRFR-haircuts are restrictive for brown collateral, they have expansionary effects on green collateral, as will be sketched in this section.

The first effect of expansionary collateral modifications is mirror-inverted to the restrictive case: preferential haircuts and eligibility entail that the market value of green assets increases. This improves funding conditions for green firms. Besides, access to GTLTROs is facilitated for holders of green assets as haircuts are reduced and some green assets are accepted as collateral in the first place. Favourable treatment of green assets by the ECB possibly increases the supply of these assets. This likely ameliorates their liquidity and reduces trading costs. The decline in trading costs seems to be particularly beneficial as trading costs have been notoriously higher for green bonds compared to conventional ones, constituting a further obstacle for their market adoption (Fender et al., 2019).

In terms of participation in GTLTROs for liquidity conversion, there seems to be a strong rationale for holders of green securities to participate in GTLTROs: as green securities are typically non-HQLAs (Campiglio, 2016) encumbering green securities allows banks to upgrade their liquidity. However, concerns might be voiced with respect to the change in credit quality in case CRFR-haircuts or a green eligibility extension are adopted. This is because the ECB could load on more credit risks if CRFRs cannot be played off against general default risks. This concern would become pertinent if the ECB were to consider changing the catalogue of eligible collateral to include more green collateral either by replacing brown with green collateral or by enlarging the catalogue by adding green collateral. To exemplify the implications of a 'brown for green' replacement the effect of a minimum quota of green collateral can be tested.

To do so, I look at differences in credit ratings between green and conventional bonds. According to the Bank for International Settlements (BIS), ratings of green and conventional bonds have been converging in terms of credit rating in recent years (Fender et al., 2019). Still, green corporate bonds seem to be a bit riskier, as the percentages of bonds per ECB rating category in Table 3 show. Remarkably, the mass of conventional bonds is slightly more concentrated in the upper-middle rating spectrum which results in a slightly better rating average (A+ for conventional bonds compared to A- for green bonds)[12]. A 10% quota for instance, which would mean that at least 10% of collateral pledged in GTLTROs have to be green, would only imply a minor deterioration in credit quality. Employing the somewhat coarse meshed ECB rating, this modification would not change the mean ECB portfolio rating which would still be A+. As averages likely blur tail risks, looking at the proportion of 'below BBB- bonds' included in the ECB's

[12] To calculate averages, I used numerical values (1 to 4) as auxiliary variables. Hence, for this calculation, I made the assumption that ratings can be treated as values on an interval scale with differences between rating classes being equidistant.

collateral framework by such a policy might be more telling. Below BBB- bonds normally would not be accepted by the Eurosystem. However, when correcting for CRFRs characteristics, these bonds would receive a better risk grading and end up eligible.

Table 3: Credit Rating of Green and Conventional Bonds

Rating	Green Bonds (%)	Conventional Bonds (%)
AA+ to AA-	9	7
A+ to A-	39	67
BBB+ to BBB-	47	27
Below BBB-	5	–
Average	A- (2.48)	A + (2.22)

Source: Fender et al. (2019), own diagram

The implication is that the ECB would load on conventional risks beyond its usual tolerance. To concretize, a 25 % green bond quota would be tantamount to including 1.25% of below BBB- bonds, the same number being 0.5% for a 10% quota.

Even if this uptake of risks is small in scale, accepting BBB- bonds might be incompatible with the tenets of the ECB's collateral policy. The ECB assumes low-rated collateral "to be more information-intensive and more difficult to value" and to have a "higher probability of default, and an even higher probability of downwards migration" (Bindseil et al., 2017, p.12). This complicates its prudential handling. Given this stance on credit quality, a green collateral extension excluding 'below BBB- bonds' might be better compatible with the ECB's collateral policy principles. This could be obtained at the little cost of excluding the mentioned 5% of below BBB- bonds, confining to include the remaining 95% of green bonds. Regarding compatibility with the ECB's tenets, collateral policies are also required to align with the principle of 'market neutrality'. Whether this is true for the collateral policies considered here is part of a more general debate which I will cover in Chapter 6.

To sum up, the usability of GTLTROs for liquidity transformation could be lowered if they include a restrictive green collateral modification. Such a modification would entail that GTLTROs get less usable for liquidity transformation. Given the large share of brown HQLAs (61%) involved in banks' daily operations, the contractive effect would be sizable. Expansionary collateral modification can foster green

investment as market values of green securities increase. Thereby, they could lower funding costs for green businesses. Risks on the ECB's balance sheet would only slightly increase through such a measure.

Noteworthy, GTLTROs could be implemented without the financial stability issues discussed here if collateral policies are left untouched (NGFS, 2021; van't Klooster & van Tilburg, 2020). Policy-makers have to make the trade-off of accepting potential adverse financial stability issues sketched here versus allowing GTLTROs to have a broad impact on assets' market values through a green collateral modification. While in the absence of a green collateral modification GTLTROs would primarily affect banks' lending pattern (Cox, 2020a), a green collateral modification would have a broader influence as banks would also have to hold a sufficient amount of green assets to deposit as collateral. Potentially, this would foster a greening of banks' entire portfolios, not just of their lending scheme. In the next chapter, I will scrutinize the third dimension of GTLTROs' impact, market effects.

6. Market Effects of GTLTROs

GTLTROs alter the funding conditions of biding banks by giving these banks access to subsidized funding. In this way, GTLTROs ameliorate the competitiveness of banks that participate relative to those which do not. Both, bidding banks and non-bidding banks are likely to strategically react to this change in funding framework conditions. This chapter studies these 'second round repercussions' of GTLTROs centring on funding externalities in the first part and turning to the question of the implications of a 'green selective' transmission in the second part.

6.1 Funding Externalities

GTLTROs equip banks that partake in the operations with funds. For this reason, these banks might not need to issue green bonds to obtain finance. Consequently, the overall quantity of green bonds in the market is lowered which lets green bond prices soar. Green funding costs in the banking sector both for participating and non-participating banks decrease since higher green bond prices reduce the interest expense of issuers. This sequence of effects, referred to as funding externalities (Andreeva & García-Posada, 2020), is visualized in the chain of effects below.

Figure 7: Funding Externalities

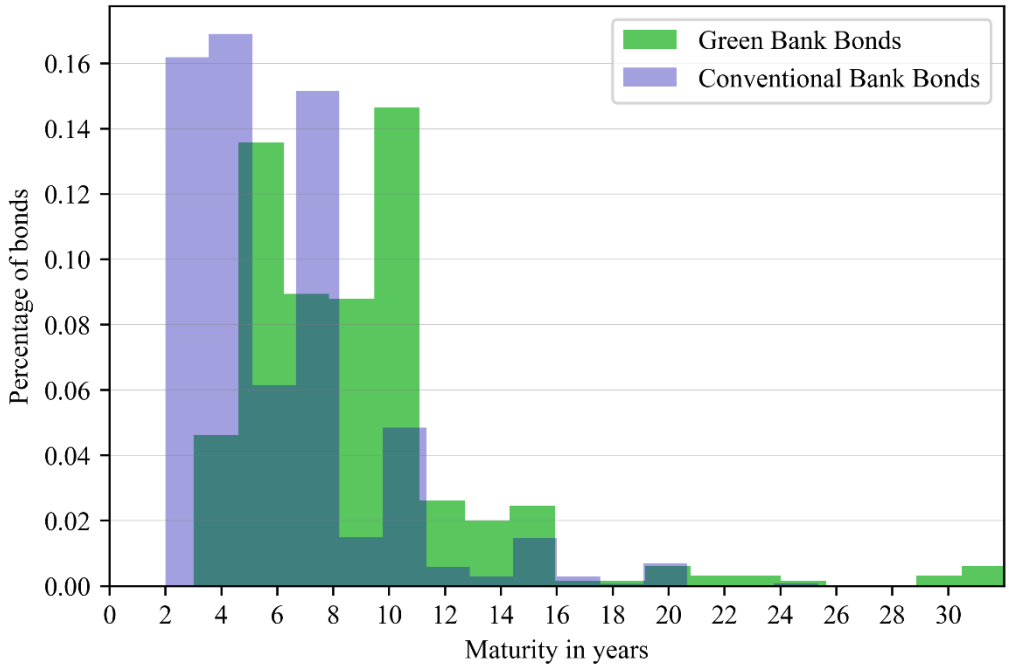
$$\textit{Funding via GTLTRO} \uparrow \Rightarrow \textit{ Green bond supply of participating banks} \downarrow \Rightarrow \textit{Green bond prices} \uparrow \Rightarrow \textit{ Green funding costs for banks} \downarrow$$

Source: Own diagram

A presupposition for funding externalities to occur is that GTLTRO funds and green bank bonds[13] (GBBs) are substitutes. Only then might participation in GTLTRO prompt banks to issue less or no green bank bonds. For TLTRO funds and conventional bank bonds such a substitutive relationship was manifest, as Andreeva and García-Posada (2020) show. To check whether the same is true for GTLTROs and green bank bonds, I look at two criteria decisive for substitutability, namely maturity and the risk perception of banks by the market.

Starting with maturity, if maturities of GTLTRO funds and GBBs diverged, these funding means would have a differing funding functionality for banks. In this way, it could be convenient for banks to use both forms of financing to cover different time spans. In this case, GTLTROs and GBBs would not be substitutes. Sticking with the assumed maturities of past TLTRO operations, GTLTRO funds would have a maturity of 3 to 4 years. To compare the maturities of green and conventional bank bonds, I have juxtaposed their respective maturity distributions below.

Figure 8: Maturity of Green and Conventional Bank Bonds



Source: Refinitiv Eikon, own diagram

Visibly, the green bank bond distribution is considerably shifted to longer maturities. Because the distributions are left-skewed with some outliers exhibiting very long maturities, the median likely better summarizes the distribution's characteristics than the mean. The median maturity is 7 years for GBBs which is in line with statistics by Ehlers and Packer (2017) and 5 years for conventional bank bonds. This seems

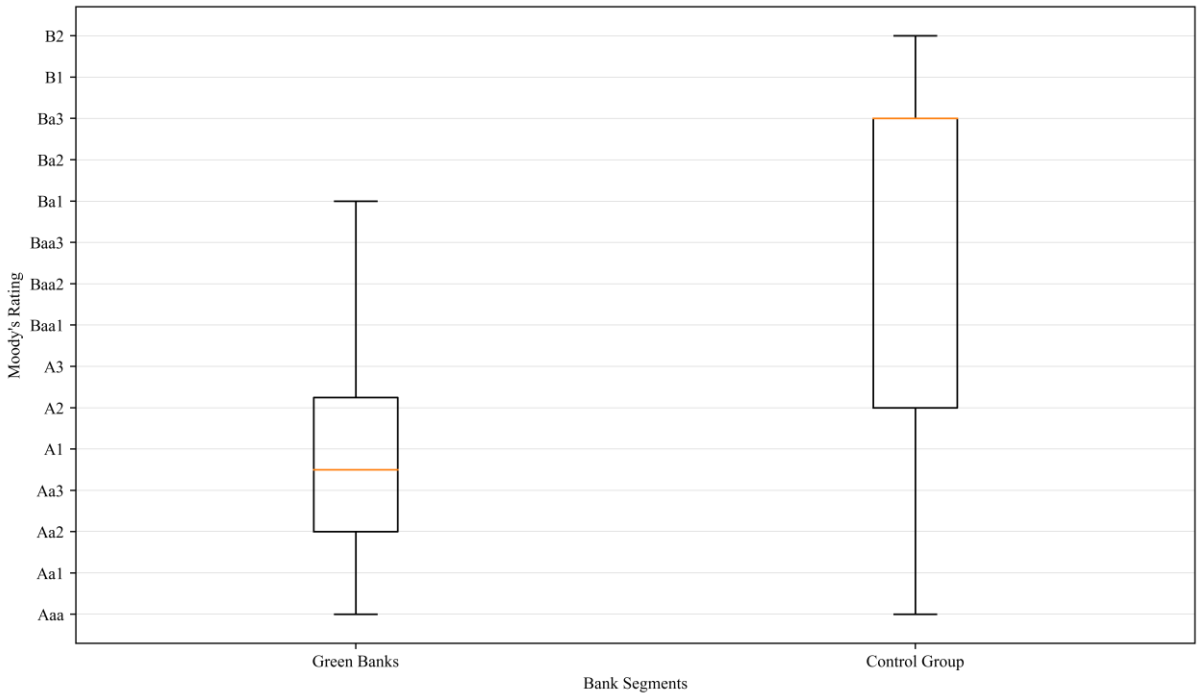
[13] GBBs are green bonds issued by banks.

to indicate that while maturities were sufficiently akin between TLTROs (3 to 4 years) and conventional bank bonds (5 years) the difference in maturity is more pronounced between GTLTROs (3 to 4 years) and GBBs (7 years). Substitution of GTLTROs with green bank bonds, except for bonds with maturities close to the GTLTRO term, is thus less likely as GBBs seem to be typically used for longer maturities. As Ehlers and Packer's (2017) finding that green bonds still trend towards longer maturities suggests, this functional dichotomy will likely prevail. Thus, in terms of maturity GTLTRO funds and GBBs are likely not substitutes.

Next to maturity, I assume that the risk perception of banks by the market is relevant for whether banks consider substituting GBBs with GTLTROs. In fact, this point is less about substitutability than it is about costs. For banks that have the reputation of being risky and thus have to offer higher premia when emitting bonds, GTLTROs might be the better choice since banks' risk is priced in to a lesser extent. Hence, for these banks, GBBs do not constitute a comparable alternative, prompting them to lower their bond issuance.

To be able to say more about the risk characteristics of green banks, I looked at the differences in credit default spreads (CDS) for 'green banks' that is banks that either issued green loans or green bonds (or both) and those which did not. I used CDS listed in 2021 on Refinitiv Eikon. The results are visualized in Figure 9: in general, green banks, are not perceived riskier than those exclusively operating in conventional markets. On average, green banks were ranked A2 by Moody's, compared to Ba1 for conventional banks. This piece of evidence portends that in general high-risk premia will not constitute a reason why green banks keep from issuing bonds. Despite this being true for the average bank, some banks might still face high premia and fare better taking up GTLTROs. Conversely, worse credit ratings of conventional banks might have been a driver for TLTRO up-take. This effect would cease to apply in GTLTROs, a factor pointing to lower participation in GTLTROs.

Figure 9: Rating of Green and Conventional Banks



Source: Refinitiv Eikon, own diagram

Apart from banks, funding externalities could also materialize for corporations. Firms could be incentivized to take up more green loans taking advantage of attractive lending offered by banks which source GTLTRO funds. If they take that option, this might prompt them to emit fewer bonds. Whether this happens is more difficult to assess than in the case of bank bonds. This is because the maturity of green loans might differ from the maturity of GTLTRO means under the condition that banks step in transforming maturities[14]. In principle, this paves the way for corporations to cherry-pick green loans with maturities they cannot cover in a cost-efficient way with green bonds. For instance, a corporation might know from experience that green bonds with a maturity of 10 years sell well compared to bonds with shorter maturities. Hence, this corporation will use loans to cover shorter maturities and bonds to cover longer maturities. In total, GTLTROs would imply that fewer corporate green bonds are issued for less favourably selling maturities. The result is that funding externalities occur in the corporate sector: GTLTROs likely lead to a diminished supply of corporate bonds, entailing more favourable funding conditions for firms.

I take the findings of this section to indicate that GTLTROs will not induce large funding externalities in banking sector funding markets. This is to the benefit of the GBB market the evolvement of which might

[14] Arguably, banks might have an interest not to overextend maturities as GTLTRO maturities are limited to 3 to 4 years and granting loans of longer terms might lead to liquidity bottlenecks.

have been dampened if funding externalities prevailed. However, in the corporate funding market funding externalities are more likely given that loan maturities are flexible.

This makes the substitution of loans and bonds conceivable. In the next section, I will turn to market effects and implications for transmission that might arise due to the targeted nature of GTLTROs.

6.2 Selective Monetary Policy Transmission

One objection often raised against green monetary policy which is equally valid for GTLTROs is that it would counteract the homogenous transmission of monetary policy impulses through all sectors of the economy (Issing, 2019). In this way, green monetary policy, as a type of 'selective monetary policy', (Gischer et al., 2004, p. 283) would transmit monetary impulses and subsequent positive economic benefits to selected sectors only.

This critique is based on the idea that central banks should stick to the notion of 'market neutrality'. Market neutrality has long been used as a practical heuristic of the ECB's open market operations. It states that ECB interventions should be designed so as to "minimize the impact on relative prices … and unintended side effects on market functioning" (Hercelin, 2019). Notably, this notion of market neutrality is not universal. Market neutrality only applies to eligible counterparties that fit with the ECB's policy objectives.

There are two replies to this concern: the first one comes from Isabel Schnabel who advocates replacing the principle of market neutrality with 'market efficiency'. The latter refers to a policy stance that aims at minimizing externalities (Schnabel, 2021b). Though in conflict with market neutrality, the selectiveness implied by green monetary policy would align with market efficiency. This is because green monetary policy contributes to reducing climate externalities in the form of CRFRs. Through factoring in CRFRs as aimed at by green monetary policy, prices and risk assessment would receive a corrective tweak and are no longer distorted. Resulting CRFR-adequate investments and correct relative prices would enhance market efficiency. Thus, assuming market efficiency, the selectiveness of green monetary policy is no longer problematic.

For a sceptic towards market efficiency, a second response is that the favourable treatment of some sectors should be accepted if ultimately conducive to the ECB's mandate. A reason why one might find this argument appealing is that the ECB seems to have acted with a similar rationale during and in the aftermath of the European debt crisis when extensively and selectively purchasing sovereign debt of crisis shaken countries. In summary, green monetary policy proponents do not necessarily question the ECB's mandate but rather regard a green selective monetary policy as necessary to accomplish it. Whether this claim is correct, is an empirical question that shall be answered at the time when evidence on implemented green monetary policy is available.

7. Concluding Remarks and Topics for Future Research

In this thesis, I aimed to give an impact assessment of GTLTROs. GTLTROs are central bank refinancing facilities in which lending rates are conditional on banks' green lending performance: banks that increment lending to green credit-takers are rewarded with lower borrowing rates. Assessing the expected impact of GTLTROs, I first focused on their effect on lending. I have argued that GTLTROs exhibit a cost advantage in terms of interest costs and thus are likely to attract extensive participation. Turning to the pass-through of lending, I worked out a possible distortion that could arise as banks are differently positioned to restructure their portfolio given the changed funding environment implied by GTLTROs. Following van't Klooster and van Tilburg (2020), I proposed correction factors to remedy this distortion. I further pointed to challenges for pass-through related to the uncertainty, high up-front costs and longer maturities involved in green lending relationships. Here, GTLTROs face considerable hurdles but could also, if successful in diminishing these hurdles, unravel a strong impact by unchaining bank lending which has up till now been deadlocked for green investments (de Haas & Popov, 2019). Regarding the impact of GTLTROs on financial stability I argued that their usefulness for liquidity conversion and thus participation would decline if they included a restrictive green collateral modification. As opposed to this, the downgrading effect of expansionary green collateral modifications on credit risk is small. Here, collateral policies have been identified as a powerful adjustment skew with which policy-makers could calibrate the policy focus on 'conventional' financial stability versus reduction of CRFRs.

In terms of market effects, GTLTROs can be expected to entail almost no funding externalities for banks but they likely do in the corporate sector. Since the selective impact of green monetary policy has been subject to critique by numerous sceptics, I have defended the favouritism implied in green monetary policy stressing its corrective tweak on prices and its mandate compatibility.

In summary, this thesis has found that GTLTROs likely are an effective policy instrument that spurs lending while factoring in CRFRs. Given that side effects on markets are favourable as GBBs are not crowded out and side effects on financial stability controllable through the adjustment screw of collateral policies, GTLTROs seem better suited than conventional refinancing operations to contribute to the ECB's mandate. In this way, GTLTROs constitute a climate change coherent upgrade of refinancing operations and can be leveraged to support future ECB accommodative policies. A limitation of this impact assessment is that its validity could only be established for the Eurozone. Further efforts are necessary to show its transferability or generalizability.

Some points, which this analysis might have identified but which could not be covered here, are promising focal points of future efforts. This is true for spill-over effects which could be induced by GTLTROs when

investors redeploy capital from overprized green assets and stocks to higher-yielding brown alternatives. Also, more research is needed to better understand the interplay of conventional and green liquidity facilities of differing maturities to allow for optimal dosage of short-term financial stability support and CRFRs guidance. Related to this, evaluating how GTLTROs could be calibrated with other monetary policy tools is critical. Moreover, this analysis has bracketed possible effects on expectations, conceivable as GTLTROs are geared to longer maturities and might lock in lending rates. Also, the application of GTLTROs in a positive interest rate environment could be analysed. Here, proposals on 'dual interest rate policies' present a promising starting point to discuss the use of GTLTROs in a positive interest rate environment (Lonergan, 2019). For these and related ambitions I hope this analysis to have provided a fruitful and illuminating point of departure.

References

Afonso, A. & Sousa-Leite, J., 2020. The transmission of unconventional monetary policy to bank credit supply: Evidence from the TLTRO. *Papers in Money, Macroeconomics and Finance*, 17 August, 88(S1), pp. 151-171.

Andreeva, D. C. & García-Posada, M., 2020. The impact of the ECB's Targeted Long-Term Refinancing Operations on banks' lending policies: the role of competition. In: *ECB Working Paper Series.* No. 2367 ed. Frankfurt: ECB.

Balfoussia, H. & Gibson, H. D., 2016. Financial conditions and economic activity: the potential impact of the targeted. *Applied Economics Letters*, 6(23), pp. 449-456.

Barkawi, A. & Monnin, P., 2015. Monetary Policy and Sustainability. In: *Inquiry Working Paper.* 15/2 ed. Geneva: CEP Council on Economic Policies.

Barmes, D. & Livingstone, Z., 2021. *The Green Central Banking Scorecard: How Green Are G20 Central Banks And Financial Supervisor.* [Online] Available at: https://positive-money.org/publications/green-central-banking-scorecard/ [Accessed 13 July 2021].

Bats, J. & Hudepohl, T., 2019. Impact of targeted credit easing by the ECB: bank-level evidence. In: *DNB Working Paper.* No. 631 ed. Amsterdam: De Nederlandsche Bank.

Benetton, M. & Fantino, D., 2018. Targeted monetary policy and bank lending behavior. In: F. Journal of Financial Economics (JFE), ed. *Bank of Italy Temi di Discussione (Working Paper)* . No. 1187 ed. s.l.:s.n., pp. 1-26.

Bindseil, U., Corsi, M., Sahel, B. & Visser, A., 2017. The Eurosystem collateral framework explained. In: *ECB Occasional Paper Series.* 189 ed. Frankfurt: European Central Bank.

BIS, 2010. *Basel III: international regulatory framework for banks.* [Online] Available at: https://www.bis.org/bcbs/basel3.htm [Accessed 10 July 2021].

Blanchard, O. & Illing, G., 2014. *Makroökonomie.* 6 ed. Hallbergmoos: Pearson.

Bloomberg, 2015. *https://www.bloomberg.com.* [Online] Available at: https://www.bloomberg.com/professional/blog/is-recovery-in-sight-june-tltro-potential-bond-market-catalyst/ [Accessed 19 July 2021].

Bolton, P. et al., 2020. *The green swan - Central banking and financial stability in the age of climate change,* Basel: Bank for International Settlements.

Campiglio, E., 2016. Beyond carbon pricing: The role of banking and monetary policy in financing the transition to a low-carbon economy. *Ecological Economics*, Volume 121, pp. 220-230.

Carney, M., 2015. *Breaking the Tragedy of the Horizon – Climate Change and Financial Stability.* London: Bank for International Settlements.

Cassola, N. & Koulischer, F., 2019. The collateral channel of open market operations. *Journal of Financial Stability*, April, Volume 41, pp. 73-90.

Climate Bonds Initiative, 2017. *Green Covered Bonds: Aufbau grüner Deckungswerte.* [Online] Available at: https://www.climatebonds.net/files/files/Green Covered-_Bonds_Deutsch.pdf [Accessed 6 August 2021].

Cox, J., 2020a. *https://www.globalcapital.com.* [Online] Available at: https://www.global-capital.com/article/b1ns6fl2394ldx/ecb39s-vansteenkiste-engages-with-green-tltro-idea [Accessed 27 July 2021].

Cox, J., 2020b. *www.globalcapital.com.* [Online] Available at: https://www.globalcapital.-com/article/b1nlfwhdn4j8m1/ecb-to-look-at-green-tltros [Accessed 25 July 2021].

Dafermos, Y. et al., 2021. *Greening the Eurosystem Collateral Framework.* [Online] Available at: https://www.greenpeace.de/sites/www.greenpeace.de/files/-studie_greening_the_eurosystem_collateral_framework-report-final_0.pdf [Accessed 10 August 2021].

Dafermos, Y., Gabor, D., Nikolaidi, M. & van Lerven, F., 2021. Greening the UK financial system - a fit for purpose approach. *Suerf Policy Note*, March, Issue 226, pp. 1-14.

Dafermos, Y., Nikolaidi, M. & Galanis, G., 2018. Climate Change, Financial Stability and Monetary Policy. *Ecological Economics*, 20 June, Volume 152, pp. 219-234.

de Haas, R. & Popov, A., 2019. https://poseidon01.ssrn.com. In: *ECB Working Paper.* Frankfurt: ECB.

Dikau, S. & Volz, U., 2019. Central Bank Mandates, Sustainability Objectives and the Promotion of Green Finance. In: *SOAS Department of Economics Working Paper.* No.222 ed. London: SOAS University of London.

Dikau, S. & Volz, U., 2021. Out of the window? Green monetary policy in China: window guidance and the promotion of sustainable lending and investment. In: *Grantham Research Institute on Climate Change and the Environment Working Paper.* No. 360 ed. London: Centre for Climate Change Economics / Grantham Research Institute on Climate Change and the Environment.

Dikau, S., Volz, U. & Robins, N., 2020. A Toolbox of Sustainable Crisis Response Measures for Central Banks and Supervisors. In: *INSPIRE Briefing Paper.* 2. ed. London: INSPIRE.

Drechsler, I., Savov, A. & Schnabl, P., 2017. The Deposits Channel of Monetary Policy. *The Quarterly Journal of Economics*, November, 132(4), pp. 1819-1876.

ECB, 2015. *https://eur-lex.europa.eu.* [Online] Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015O0035&qid=1625823801277 [Accessed 9 July 2021].

ECB, 2021a. *https://sdw.ecb.europa.eu.* [Online] Available at: https://sdw.ecb.europa.eu--/browse.do?node=9691294 [Accessed 8 August 2021].

ECB, 2021b. *https://www.ecb.europa.eu.* [Online] Available at: https://www.ecb.europa.eu/-press/pr/date/2021/html/ecb.pr210708_1~f104919225.en.html [Accessed 27 July 2021].

ECB, 2021c. *https://www.ecb.europa.eu.* [Online] Available at: https://www.ecb.europa.eu/-press/pr/date/2021/html/ecb.pr210708~dc78cc4b0d.en.html [Accessed 8 August 2021].

ECB, 2021d. *www.ecb.europa.eu.* [Online] Available at: https://www.ecb.europa.eu/-mopo/implement/omo/tltro/html/index.en.html [Accessed 27 July 2021].

Ehlers, T. & Packer, F., 2017. Green bond finance and certification. In: *BIS Quarterly Review.* Basel: Bank of International Settlements.

European Commission, 2021. *https://ec.europa.eu/.* [Online] Available at: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en [Accessed 27 July 2021].

Fatica, S., Panzica, R. & Rancan, M., 2021. The pricing of green bonds: Are financial institutions special?. *Journal of Financial Stability,* 30 March, pp. 1-20.

Fender, I., McMorrow, M., Sahakyan, V. & Zulaica, O., 2019. *Green bonds: the reserve management perspective.* [Online] Available at: https://www.bis.org/publ/qtrpdf/r_qt1909f.pdf [Accessed 27 July 2021].

Fiedler, S., Hanisch, I., Jannsen, N. & Wolters, M., 2017. Effectiveness of Unconventional Monetary Policy in the Euro Area: An Assessment Based on a Literature Survey. *Credit and Capital Markets*, 50(4), pp. 455-488.

Giraudet, L.-G., Petronevich, A. & Faucheux, L., 2019. *How do lenders price energy efficiency? Evidence from personal consumption loans,* Paris: Banque de France.

Gischer, H., Herz, B. & Menkhoff, L., 2004. *Geld, Kredit und Banken.* 3. ed. Berlin: Springer-Verlag.

Grandia, R., Hänling, P., Lo Russo, M. & Åberg, P., 2019. https://www.ecb.europa.eu. In: *Occasional Paper Series.* No. 218 ed. Frankfurt: European Central Bank.

Harrison, C. & Muething, L., 2021. *Climate Bonds Initiative.* [Online] Available at: https://www.climatebonds.net/files/reports/cbi_sd_sotm_2020_04d.pdf [Accessed 3 August 2021].

Harrison, C., Partridge, C. & Tripathy, A., 2020. What's in a Greenium: An Analysis of Pricing Methodologies and Discourse in the Green Bond Market. *The Journal of Environmental Investing*, 2 September, Volume 10.

Hercelin, N., 2019. *https://www.positivemoney.eu.* [Online] Available at: https://www.positivemoney.eu/2019/09/ecb-market-neutrality-doctrine/ [Accessed 27 July 2021].

IPCC, 2018. *Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable.* s.l., Intergovernmental Panel on Climate Change, pp. 93-174.

Issing, O., 2019. *"Eine grüne Geldpolitik kann es nicht geben".* [Online] Available at: https://www.wiwo.de/politik/europa/ezb-eine-gruene-geldpolitik-kann-es-nicht-geben/25322158.html [Accessed 10 August 2021].

Jaffee, D. & Stiglitz, J., 1990. Credit rationing. In: B. M. Friedman & F. Hahn, eds. *Handbook of Monetary Economics.* Chicago: Elsevier, pp. 837-888.

Kenton, W., 2020. *Investopedia.* [Online] Available at: https://www.investopedia.com/terms/c/coveredbond.asp[Accessed 6 August 2021].

Kihara, L., 2021. *https://www.reuters.com.* [Online] Available at: https://www.reuters.com/-business/sustainable-business/bank-japans-new-scheme-approach-climate-change-2021-06-18/ [Accessed 27 July 2021].

KPMG, 2020. *Going Green: ie EU-Taxonomie.* [Online] Available at: https://hub.kpmg.de/-hubfs/LandingPages-PDF/sustainable-finance-newsletter-eu-taxonomy sec.pdf ?utm-_campaign=Going%20Green%3A%20%20- Die%20EU-Taxonomie&utm_medium=email&_hsmi=83834925&_hsenc=p2ANqtz-_-OsXQPdvw7MFGkRPjTnEP3-MRmmNgdWhdjPD-xJstix_JkUNpybyNofLtTyp [Accessed 4 August 2021].

Krämer, J., 2021. *Die Illusion grüner Geldpolitik.* [Online] Available at: https://www.handelsblatt.com/meinung/gastbeitraege/gastkommentar-die-illusion-gruenergeldpolitik/-27262976.html?ticket=ST-2737982-W56hOLMXVkpRu45iavnQ-ap3 [Accessed 2 August 2021].

Lagarde, C., 2021a. *Climate change and central banking.* [Online] Available at: https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp210125~f87e826ca5.en.html [Accessed 13 July 2021].

Lagarde, C., 2021b. *Climate Change and Central Banks: Analysing, Advising and Acting.* [Online] Available at: https://www.ecb.europa.eu/press/key/date/2021/-html/ecb.sp210711~ffe35034d0.en.html [Accessed 13 July 2021].

Laine, O.-M., 2021. The Effect of Targeted Monetary Policy on Bank Lending. *Journal of Banking and Financial Economics*, 18 June, 15(1), pp. 25-43.

Lane, T., Aylmer, C. & Keller, J., 2015. Central bank operating frameworks and collateral markets. In: *CGFS Papers.* No. 53 ed. Basel: Bank for International Settlements.

Lonergan, E., 2019. *Dual interest rates always work.* [Online] Available at: https://www.philosophyofmoney.net/dual-interest-rates-always-work/ [Accessed 7 August 2021].

Marois, T., 2017. How Public Banks Can Help Finance a Green and Just Energy Transformation. In: M. Bélanger Dumontier, ed. *Public Alternatives issue brief.* Amsterdam: Transnational Institute.

Migliorelli, M. & Dessertine, P., 2019. *The Rise of Green Finance in Europe Opportunities and Challenges for Issuers Investors and Marketplaces.* 1. ed. Paris: Springer Nature Switzerland.

Monnin, P., 2018. Integrating Climate Risks into Credit Risk Assessment - Current Methodologies and the Case of Central Banks Corporate Bond Purchases. *CEP Discussion Notes*, December, pp. 1-24.

Mouabbi, S. & Sahuc, J.-G., 2019. Evaluating the Macroeconomic Effects of the ECB's. *Journal of Money, Credit and Banking*, June, 51(4), pp. 831-859.

Nelson, D. & Shrimali, G., 2014. Finance Mechanisms for Lowering the Cost of Renewable Energy in Rapidly Developing Countries. In: *A CPI Series.* Delhi: Climate Policy Initiative.

NGFS, 2021. *Adapting central bank operations to a hotter world - Reviewing some options*, s.l.: Network for Greening the Financial System.

Nyborg, K. G., 2017. *Collateral Frameworks The Open Secret of Central Banks.* 1. ed. Cambridge: Cambridge University Press.

Punzi, M. T., 2018. Role of Bank Lending in Financing Green Projects: A Dynamic Stochastic General Equilibrium Approach. In: *ADBI Working Paper Series.* No. 881 ed. Tokyo: Asian Development Bank Institute.

Raberto, M. et al., 2019. From financial instability to green finance: the role of banking and credit market regulation in the Eurace model. *Journal of Evolutionary Economics*, 29(1), pp. 429-465.

Renne, J.-P., 2014. Options Embedded in ECB Targeted Refinancing Operations. In: *Banque de France Working Paper 518.* Paris: Banque de France.

Scharfstein, D. & Sunderam, A., 2016. *Market Power in Mortgage Lending and the Transmission of Monetary Policy.* [Online] Available at: https://www.hbs.edu/-ris/Publication%20Files/Market%20Power%20in%20Mortgage%20Lending%20and%20the%20Transmission%20of%20Monetary%20Policy_8d6596e6-e073-4d11-83da-3ae1c6db6c28.pdf [Accessed 14 July 2021].

Schnabel, I., 2020. *Never waste a crisis: COVID-19, climate change and monetary policy.* [Online] Available at: https://www.ecb.europa.eu/press/key/date/2020/html/ecb-.sp200717~1556b0f988.en.html [Accessed 13 July 2021].

Schnabel, I., 2021a. *From green neglect to green dominance?.* [Online] Available at: https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp210303_1~f3df48854e.en.html [Accessed 13 July 2021].

Schnabel, I., 2021b. *From market neutrality to market efficiency.* [Online] Available at: https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp210614~162bd7c253.en.html [Accessed 24 July 2021].

Schoenmaker, D., 2021. Greening monetary policy. *Climate Policy*, 21(4), pp. 581-592.

Siedenbiedel, C., 2021. *Der Streit um die grüne Geldpolitik.* [Online] Available at: https://www.faz.net/aktuell/finanzen/der-streit-um-die-gruene-geldpolitik-17242817.html [Accessed 28 July 2021].

Stiens, T., 2021. *Grüne Geldpolitik der Zentralbanken: Dürfen die das?.* [Online] Available at: https://www.wiwo.de/politik/europa/ezb-fed-und-co-gruene-geldpolitik-der-zentralbanken-duerfen-die-das/26798676.html [Accessed 2 August 2021].

Sugo, T. & Vergote, O., 2020. Who takes the ECB's targeted funding. In: *ECB Working Paper.* No. 2439 ed. Frankfurt: ECB.

TCFD, 2020. *Task Force on Climate-related Financial Disclosures 2020 Status Report.* [Online] Available at: https://assets.bbhub.io/company/sites/60/2020/09/2020-TCFD_Status-Report.pdf [Accessed 27 July 2021].

van't Klooster, J. & van Tilburg, R., 2020. *Targeting a sustainable recovery with Green TLTROs,* Brussels: Positive Money Europe.

Will, F. & von Koss, S., 2016. *Covered Bond Outlook 2017: Between a Rock and a Hard Place,* s.l.: HSBC Global Research.

World Government Bonds, 2021. *www.worldgovernmentbonds.com.* [Online] Available at: http://www.worldgovernmentbonds.com/bond-historical-data/france/5-years/ [Accessed 9 July 2021].

Appendix

Interest Rate Cost Advantage Calculation (see Section 4.1):

To compute the funding costs of GTLTROs, the first step is to account for haircuts. The application of haircuts by the Eurosystem leaves the bank with a discounted remainder. For this amount, the bank has to collect funds on an unsecured basis (Will & von Koss, 2016). To exemplify, a bank that receives EUR 80 after having pledged a security worth EUR 100, has to refund EUR 20 on an unsecured basis. I proxy this unsecured remainder with green senior unsecured bond yields building an approach explained in Sugo and Vergote (2020) described by Will and von Koss (2016). Yields and further data are taken from Refinitiv Eikon.

As stated in Section 4.1, I stipulate that a bank takes up EUR 1 m of GTLTRO funds. For credit institutes, the ECB applies Category IV-haircuts which for the given maturity of 4 years amount to 10.4% (ECB, 2015). Thus, of the EUR 1 m, EUR 104 000 have to be accounted for as if they were green senior uncovered bonds (Sugo & Vergote, 2020). I get an average yield of 0.4362124 % for this class. For the remaining EUR 896 000, the GTLTRO rate applies. Here I compare two scenarios, the lower rate of minus 0.4%, which is charged to banks that lend above or equal to their benchmark and the baseline rate of 0.0%.

Next, I have calculated costs for green covered bonds. I take green covered bonds with a maturity comparable to that of GTLTROs as the bond class of reference. I get an average yield of 0.2417006%. Yields are considerably lower than what other authors have found to be typical for green bonds (e.g. Fatica et al. (2021), 3.02 %) which can be explained by typically longer maturities of green bonds (Harrison & Muething, 2021). Following Will and von Koss (2016), I add a new issuance premium of 5 basis points to yields of green bonds so that green bond yields are at 0.2917006%.

For the robustness check, I enlarged the sample of 'green covered senior class bonds' to include 'green covered non-senior class bonds'. Here, I get an average yield of 0.200395%.

Yield* is the green covered bond yield at which GTLTRO interest costs are equal to green covered bond interest costs. To obtain Yield*, I equated GTLTRO costs for the respective scenarios with green covered bond costs.

Below, the formula used to calculate the cost advantage is given:

$$Cost\ Advantage\ (\%) = 1 - \frac{1\,000\,000 + Interest\ Costs_{GTLTROs}}{1\,000\,000 + Interest\ \ Costs_{Green\ Bonds}}$$

Non-plagiarism Statement

By submitting this thesis the author declares to have written this thesis completely by himself, and not to have used sources or resources other than the ones mentioned. All sources used, quotes and citations that were literally taken from publications, or that were in close accordance with the meaning of those publications, are indicated as such.

The work has not been submitted in the same or similar form to any other examination authority.

Bayreuth, August 12, 2021

Signature: