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Green Bonds: the Sovereign Issuers' Perspective

by Raffaele Doronzo, Vittorio Siracusa and Stefano Antonelli*

Abstract

After a brief illustration of sovereign green bonds' features, this paper describes the market evolution and identifies the main benefits and costs for sovereign issuers. The financial performance of these securities is then analysed. In the primary market, the yields at issuance of sovereign green bonds are compared with the yields of similar non-green bonds. In the secondary market, the evolution of the yields of the sovereign green bonds issued by France, Belgium, Ireland and the Netherlands is analysed. The results show that the sovereign green bonds' performance is essentially in line with that of conventional bonds. However, this conclusion does not represent a disincentive to enter this market, since the choice of issuing this kind of security does not simply hinge upon economic convenience valuations: green bonds are a valid tool for mitigating environmental risks and coping with the intergenerational trade-offs implied by climate-related policies.

JEL Classification: H23, H63, Q56.

Keywords: green bonds, public debt, debt management.

Sintesi

Dopo aver illustrato le principali caratteristiche dei green bond emessi da stati sovrani, il lavoro descrive l'evoluzione del mercato e identifica i benefici e i costi per gli emittenti. Viene successivamente analizzata la performance di tali titoli. Con riferimento al mercato primario, se ne confronta il rendimento all'emissione con quello di obbligazioni sovrane convenzionali aventi caratteristiche finanziarie simili. Per quanto riguarda il mercato secondario, vengono esaminati gli andamenti dei rendimenti dei titoli green sovrani di Francia, Olanda, Belgio e Irlanda. I risultati mostrano che la performance dei green bond di emittenti sovrani è sostanzialmente in linea con quella dei titoli convenzionali. Tale conclusione non costituisce tuttavia un disincentivo a entrare in questo mercato, in quanto la scelta di collocare titoli di questo tipo non si basa esclusivamente su valutazioni di convenienza economica: essi sono un valido strumento per mitigare i rischi climatici e per gestire i trade-off intergenerazionali impliciti nelle politiche di contenimento di tali rischi.

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1. Introduction[1]

A green bond (GB) is a fixed income security used to finance eco-sustainable projects that result in environmental benefits. The difference with respect to a regular bond is the explicit commitment of the issuer to exclusively use the raised funds to finance or re-finance green projects.

The origins of GBs date back to 2007 with the first issuances from supranational institutions, but the market actually burgeoned after the launch of ICMA's Green Bond Principles in 2014.[2] The GB market is still small in scale: the total outstanding amount of GBs as of September 2020 amounts to USD 996 billion, which accounts for only 0.4% of the international bond market, but it is growing fast. Despite being in its infancy, the GB market is already highly segmented, as active issuers belong to a multiplicity of industries: as a result, there are over nine thousands securities issued in 24 countries and 23 currencies of denomination.

The market is expected to grow further in the upcoming years, due to the spreading of 'environmental', 'sustainable' and 'socially responsible' investment strategies (ESG). In particular the sensibility towards climate-related issues has increased after the 2015 Paris Agreement and will likely strengthen further in the near future, following the decision by the new US Administration to re-join that agreement. The European Commission defined an action plan to finance sustainable growth, trigger private capital flows towards sustainable activities and provide investors with higher transparency and protection. This plan led to the release in 2019 of the EU harmonized taxonomy, which encompasses the activities that can be considered as green. The EU is also working on its green bond standards that will be released in 2021.

Benefits and drawbacks of GBs have been extensively discussed in the literature. From a financial perspective, green securities would theoretically broaden the investor base by attracting market operators who aim at diversifying their portfolios and carry out projects with a positive impact on the environment. This may imply a reduction in issuers' funding. GBs have other signalling and reputational advantages, but they have costs as well. Compliance with market standards involves an operational burden that makes the issuance of a green security more expensive than that of conventional bonds. Furthermore, to the extent that an issuer fails to allocate GB funding to green projects or to achieve the projected environmental targets, reputational costs could arise too.

This work analyses the GB market from the sovereign issuers' perspective. This aspect has been neglected up to now, because of scarcity of data. Indeed, sovereign green issues soared only in recent times, especially in Europe, where Poland and France pioneered the market between 2016 and 2017, followed by Belgium, Ireland and Lithuania in 2018, and the Netherlands in 2019. With the addition of some new issues in 2020, in particular from Germany, the outstanding amount of sovereign green bonds increased enough to be analysed on a stand-alone basis.

Our purpose is to identify the specific benefits and costs of issuing a GB for Sovereigns. Following a comprehensive approach, we first provide a description of the market and the regulatory frameworks, then outline the main theoretical reasons for issuing sovereign GBs, and present the empirical evidence of some selected issues. We finally analyse the financial performance of these securities, by comparing the yield at issuance of sovereign green and non-green securities from the same issuers and with the same residual maturity. On the primary market the data show on average a positive spread of GBs yields over conventional bonds that however tends to decline after issuance. Then we extend the scope to the secondary market, analysing the performance of a subsample of GBs

[1] We would like to thank Stefano Siviero, Alessandra Rollo, Gioia Cellai, Alberto Locarno, Chiara Guerzoni, Simona D'Andrea, Luca Filidi, Giampiero Guerra, Onofrio Panzarino, Emmanuela Bernardini, Massimo Molinari and Francesco Musto for their useful suggestions. The views expressed in the paper are those of the authors and do not involve the responsibility of the Bank of Italy.

[2] ICMA is a not-for-profit association, whose members are private and public sector issuers, banks and securities houses, asset managers and other investors. Its purpose is to define rules and recommendations governing the operations in the international capital and securities market.

issued by the major Euro-zone sovereign issuers (France, the Netherlands, Belgium and Ireland) over the last two years.[3] We look at Z-spreads and, in line with the prevailing literature, even after controlling for the different degree of liquidity, we find a negative spread (commonly defined as 'greenium'), albeit small, for GBs over conventional bonds. Putting these findings together, we infer that at this stage there is no remarkable difference in the performance of the two bond types.

The remainder of the paper is organized as follows. Section 2 provides a definition of GBs and their main features and standards. Section 3 retraces the development of the market and describes its composition. Section 4 identifies the main advantages and burdens for sovereign issuers, while Section 5 examines the main sovereign issuances of GB. Section 6 introduces the most relevant literature on GBs' market performance and presents our analysis of the primary and the secondary markets. Section 7 discusses our findings and conclusions.

2. Green bonds' features and standards

A GB is a fixed income security used to finance projects that result in environmental benefits. The difference with respect to a regular bond is the explicit commitment of the issuer to exclusively use the raised funds to finance or re-finance green projects. These projects should provide clear environmental benefits, which are assessed and quantified by the issuer. Thus, in addition to evaluating standard financial characteristics (such as price, coupon, maturity, and credit quality of the issuer), investors also assess the specific environmental allocation of the projects that the bonds will support. The destination of the proceeds is attested by third-party certification (ICMA 2018).

Even if GB proceeds are raised for specific green projects, their repayment is associated with the issuer and not with the success of the projects. This means that the risk of the project stays with the issuer, rather than the investor. This feature is attractive because of the higher perceived risk of green projects.

GBs are increasingly in demand from investors bound by specific environmental, social and governance (ESG) criteria, or by a policy of diversification away from fossil fuels. Issuers of GBs could benefit from both market incentives and the regulatory framework. The advantages of issuing these securities need to be weighed against potential limiting factors. Compared with regular bonds, GBs may require additional tracking, monitoring and reporting processes, as well as up-front investment to define the bond's green criteria and sustainability objectives.

Individual GBs do not necessarily imply higher hedging against climate-related financial risks, as the can be issued by 'non-green' entities.[4] The exposure to those risks is typically a function of the company's overall business. Indeed, a large share of GBs (about one fifth of the market)[5] have been issued by firms operating in sectors that generate negative environmental externalities; this suggests that these securities can be more, not less, exposed to climate-related financial risks (Ehlers, Packer 2017). However, as GBs do funnel resources towards the realization of investments with positive impacts on the environment, on aggregate they are deemed useful to mitigate environmental risks.

For the GB market to grow, investors must be able easily to identify bonds that are associated with climate-related benefits. Preliminary evidence suggests that GBs may improve firms' environmental footprint when bonds are certified by independent third parties; this highlights the

[3] At the time of the analysis the German green bond had not been issued yet.

[4] Climate-related financial risks can be divided into three categories: *physical risks* that include the consequences of droughts, floods or storms for the value of investments and productive capacity; *transition risks* that are 'stranded assets', or potential financial losses from investments losing value as a result of climate mitigation, or shifting consumer and investor preferences to greener products and technologies; *liability risks* arising from the potential impact of legal action taken by parties who have been adversely affected by climate change against firms and other economic agents that are held responsible (Carney 2015).

[5] See Section 2 for details.

importance of certification in this market (Flammer 2019). A variety of forms of certification have emerged, all aiming at ensuring that the use of funds is indeed associated with green investments.

In recent years issuing standards have gradually developed that set of non-binding rules that the fixed income industry may follow, totally or partially, on a voluntary base. The most popular sets of guidelines are those set forth by the International Capital Market Association (ICMA) in its Green Bond Principles.

The ICMA Green Bond Principles are the most widely accepted and used standards followed to issue a bond with a green label. These principles define a set of rules to be followed in the issuing process, in particular with reference to the: i) *projects selection*: projects must have the objective to address key areas of environmental concern;[6] ii) *destination of proceeds*: the issuer must track the proceeds of the bond in order to reassure the market about their being indeed used for green projects, thus avoiding green washing;[7] iii) *reporting*: issuers should make a report with a list of the projects to which GB proceeds have been allocated, as well as a brief description of the projects and the amounts allocated, and their expected impact; iv) *external review:* issuers have to use an external review to confirm the alignment of their GBs with the key features of the ICMA green bond principles; there are several levels of review that can be provided to the market that range from a basic second opinion, an evaluation by an environmental consultancy firm, to a third party assurance, a more structured and rigorous analysis from auditors giving the highest guarantee about the use and tracking of proceeds (ICMA 2018).

As the market grows, additional certified standards have emerged. One of them is the Climate Bonds Standard by the *Climate Bonds Initiative* (CBI).[8] This standard fully integrates ICMA's Green Bond Principles but offers deeper guidance as regards the use of proceeds and also offers the opportunity for certification. CBI's standards were conceived primarily to make green investments more effective in leading the transition to a low carbon and climate resilient economy. Assets that meet the CBI standard are then eligible for Climate Bonds Certification, after an approved external verification that the bond meets environmental standards and that the issuer has the proper controls and processes in place (CBI 2015).

Nevertheless, the use of a green label should be evaluated carefully by investors. There are many cases of bonds loosely linked with ecology and sustainability that only partially follow the ICMA or CBI standards. Thus far, GBs are not identified by any official lists managed by international authorities and/or institutions. The CBI maintains a database of GBs issued since 2009; while the bonds in this database have green labels, such labels are self-assigned: as a result, their inclusion in the database does not imply that the correctness of the label is certified by the CBI. Few stock exchanges provide separate identification of GBs in their lists. This is one of the reasons why GBs have been generally bought by institutional investors and are not very widespread among retail investors.

Even if substantial progress has been made, the GB market is still hindered by some critical aspects. Given that the market is still in its infancy, there are not enough data available to help investors make educated decisions; also as a result of this, investors are reluctant to take the risk (Bowman 2019). The lack of a consistent certification system, in comparison with standardized credit ratings in the non-green bond market, is a significant obstacle (Della Croce *et al.* 2011). The lack of complete standardization, despite non negligible improvements, remains a key obstacle for market participants and hampers the expansion of the market (Deschryver, de Mariz 2020).

[6] Namely renewable energy, energy efficiency, pollution prevention and control, sustainable management of natural resources and land use, biodiversity conservation, clean transportation, sustainable water and wastewater management, climate change adaptation, eco-efficient and/or circular economy, green buildings.

[7] Green washing is the practice of making a misleading claim about the environmental benefits of a project, product, service, technology or company practice.

[8] The Climate Bonds Initiative is an investor-focused not-for-profit organisation, promoting large-scale investments that will deliver a global low-carbon economy.

Several governments and international agencies are trying to support the growth of the GB market through the development of platforms, information, and active issuance. The People's Bank of China introduced the world's first national-level GB taxonomy in 2015 (NGFS 2019, People's Bank of China 2015). The European Union is working in the same direction. At the end of 2019 it introduced the EU Taxonomy, a regulation that sets six macro environmental objectives and four requirements that economic activities need to comply with to be qualified as sustainable. The taxonomy will be also the base for the definition of the EU Green Bond Standards that are expected to be issued in 2021. This will be a voluntary scheme that issuers can choose to follow when issuing GBs. The EU Green Bond Standards will be similar to the ICMA Green Bond Principles but with some specific features. In particular, the proceeds from a bond issue should be invested in activities consistent with the EU taxonomy.[9] These initiatives are reasonable options for large domestic markets but could limit the value of a particular green certification scheme to the domestic investor base.

3. Recent market evolution

In recent years international bodies have increasingly seen GBs as a valid tool to achieve the environmental objectives set at global level and, as a result, the market has considerably grown. More generally, the growing diffusion of 'sustainable' and 'socially responsible' investment strategies has led investors to integrate ESG factors into their investment strategies. GBs demand has increased accordingly, reflecting the need to make the asset allocation consistent and compliant with the ethical values increasingly recognized by the public.

The origins of GBs date back to 2007 when the European Investment Bank (EIB) launched its first Climate Awareness Bond. The World Bank issued its inaugural GB in 2008. These were followed by a small but growing stream of issues from government-related entities and local authorities. The market really started to blossom after the launch of the ICMA Green Bond Principles in 2014. The introduction of these principles marked a first step in increasing transparency for both investors and issuers (Reichelt, Keenan 2017). This gave a strong boost to both the volume and diversity of issuers. With the diffusion of climate awareness, it is not surprising that such an important vehicle to finance these initiatives has experienced rapid growth, in particular between 2015 and 2017 (Bachelet *et al.* 2019). Institutions such as the EIB, the International Bank for Reconstruction and Development and the German KfW, which by that time were already active in the market, expanded their issuance. Nevertheless, a substantial part of the growth in those years came from China, in particular with the Shanghai Pudong Development Bank and the Industrial and Communication Bank of China (ICBC). US issuers entered in 2017 with significant issuance by US municipalities (mainly to finance local transportation and water projects) and by the public agency Fannie Mae through mortgages to finance sustainable housing (Scholten 2020). Sovereign GB issuances were started by Poland in December 2016 and increased in early 2017; in the latter year, France (currently the biggest issuer) launched its EUR 7 billion first tranche of a GB, which opened the way for other sovereign GBs.[10]

According to Climate Bonds Initiative data, the total outstanding amount of GBs is approximately USD 996 billion as of September 2020, accounting for just over 0.4% of the international bond market (based on BIS statistics). Despite this being still a niche segment, two thirds of the current outstanding amount was issued in the last three years (Fig. 1). Primary market issuance reached a record high in 2019 with a total of USD 255 billion issued, up 49% from 2018 issuance. The EU was the largest market for GB issuance, standing at USD 107 billion. The proceeds from 2019 issuances have been allocated mainly to renewable energy (32%), green buildings (29%) and transportation (20%). Although the start of the year was more difficult due to Covid-19, 2020 is about

[9] See the Appendix for details.
[10] See Section 5 for details.

to be another record year for GBs issuance, particularly in Europe with the EU funding programme (by the end of September the supply in 2020 has largely kept pace with 2019).

The GB market is highly segmented: there are over nine thousands active securities issued in 24 countries and 23 currencies of denomination.[11] The concentration by issuer is relatively high, with the top ten issuers making up around one fifth of the total outstanding. At a country level, the first issuer is the United States (USD 176 billion), followed by China (USD 108 billion) and France (USD 91 billion). Europe, as a whole, is the largest continental market with over USD 330 billion outstanding. In terms of currency of denomination, three quarters of GBs are issued in US dollar or euro (30% and 44% respectively). Supranationals still represent a significant part of the market with USD 81 billion outstanding (USD 29.6 billion by the European Investment Bank, currently the main issuer; Fig. 2).

As for the industry composition, the private sector is the main issuer, with a greater presence of banks and financial institutions (particularly in China). Public issuers, including Sovereigns, today represent around a third of the market. In terms of tenor, 85% of the issuances have a maturity of less than 10 years and 40% of less than 3 years. The average duration is 6.3 years, slightly less than the one of government bonds (6.7 years). Sovereigns, on the other hand, tend to issue GBs on longer maturities between 10-20 years. As for the credit risk, the 90% of GBs belong to the investment grade space, with two thirds of the market concentrated in the higher clusters (AAA/A) thanks to the significant incidence of the supranational sector.

In recent years, the GB segment was also supported by the development of some market indices. At the current stage there are four main providers: Bank of America Merrill Lynch, Barclays MSCI, Standard & Poor's and Solactive (ICMA 2017). They adopt a market capitalization approach and differ according to the inclusion criteria (currency, minimum outstanding and residual maturity). Although the growing demand for GBs is evident in the primary market with bid-to-cover ratios on average higher than ordinary issues, on the secondary market the green indices have been performing similarly to the rest of the global bond sector.

Market growth was also significant in the asset management industry despite assets under management (AUM) in green funds is still accounting for a minor share of the total GBs outstanding. Fitch Ratings estimates that global GB fund AUM reached EUR 13.8 billion as of June 2020. Growth in the first semester 2020 was at 30%, compared with a 0.6% contraction in total bond funds globally over the same period, although the increase sprang from a much smaller base. The number of active GB funds is increasing rapidly. Fitch counted 63 GB funds worldwide at end of June 2020. Of these, 42 have been launched since 2017 (Fitch Ratings 2020). The number of passive bond vehicles investing in GBs has also grown: there are currently several ETFs, the main ones being those issued by Lyxor, iShares and MSCI.

Going ahead, with many new green initiatives on the agenda and a growing environmental awareness, investors expect the GB market to expand further in coming years. In particular the harmonization of issuing procedures in the EU through the EU Green Bond Standards is expected to boost the GBs market and further scale up sustainable economy by increasing transparency and products comparability.[12]

[11] According to Bloomberg: 1,850 bonds, 7,838 Municipals and 252 Mortgages as of September 2020.

[12] A further support to the expansion of the GB market may come from central banks, should their policies be directed to mitigate the adverse consequences of climate change. A first tentative to model a “Green QE” in a standard macroeconomic framework has been provided by Ferrari and Nispi Landi (2021).

4. Benefits and costs for sovereign issuers

Sovereigns are exposed to environmental risks and opportunities both directly (dealing with the consequences of natural disasters) and indirectly (for instance via policies and incentives for green energy). The key practical issue is what public policies are best suited for dealing with these risks and making progress on climate change mitigation. Fiscal policy is the most important tool but it may be beneficial to combine it with a strong investment program and a greener financial market (IMF 2016a, 2016b; Schnabel 2020).

Fiscal tools are instruments that directly affect the government budget and/or are implemented by fiscal authorities. They revolve mainly around carbon pricing, a broad set of policies to curb CO_2 emissions that includes the '*carbon tax*' and the '*emission trading system*' (also known as '*cap and trade*'). The carbon tax is the classical Pigouvian tax intended to correct an undesirable or inefficient market outcome due to negative externalities. An appropriate carbon tax should equal the social cost of carbon emissions (Auffhammer 2018). The '*emission trading system*' sets a limit to the emission of each firms, allowing one with low emissions to sell part of its endowment to other more polluting firms. In this way a CO_2 emissions market that keeps the aggregate level of emissions within chosen limits is created.

On a standalone basis, carbon pricing is not a sufficient condition to manage the transition towards a more sustainable economy. Higher carbon prices could carry the risk of consumers facing higher prices, without being able to switch their expenditures towards greener technologies. Strong public and private investments are useful to prevent consumers from being locked into carbon-intensive technologies. Public investments can serve as a catalyst.

Policies that affect financial markets and financial institutions are also particularly important. The central issue is developing financial instruments that promote the mitigation of climate-related risks and that can foster capital mobilization, achieving the necessary investments in green productive capital. Sovereign GB issuances could be extremely useful to achieve these goals and help to solve the intergenerational trade off in climate mitigation policies. "*Climate change can be indeed seen as a matter of intergenerational trade-off, a question of balancing current and future well-being: current generations must make sacrifices today for the improved well-being of future generations. Climate change mitigations can therefore be funded with public debt, so that future generations bear both the costs and the benefits of these actions. This intergenerational policy transforms climate change mitigation into a Pareto improving strategy where the current generation would undertake mitigation actions, while leaving future generations with a higher stock of public debt*" (Sachs 2015).

Therefore, GBs can be seen as an innovative tool to finance mitigation costs, increasing welfare and ensuring greater intergenerational equity and fairness. The mitigation effort is a corrective measure that can also be incentivized by a fiscal tool like a carbon tax. However, most of international research shows that the current level of taxation is very low and does not sufficiently reflect the social and environmental damages of specific economic activities. Furthermore, some climate economists currently presume that the carbon tax may not sufficiently rise over time, and its effect on the transition would be therefore too slow.[13] The combined use of carbon pricing and sovereign GBs could instead be more effective to finance the transition to a low-carbon economy (Orlov *et al.* 2018).

In addition to the role played by GBs from a macroeconomic perspective, countries issuing these securities can generate positive spill-over effects and exploit some financial and non-financial

[13] There are two ways to compute the appropriate taxation. The first is the so called '*efficient pricing*', a methodology that calculates the efficient cost of energy (the cost reflecting the social and environmental damages caused by a specific good or service consumption). The second and more practical approach calculates the price of a ton of CO_2 consistent with the Paris Agreement target of limit the temperature increase below 2 Celsius degrees within 2030. IMF (2019) uses the latter methodology and estimates that, on average, the appropriate carbon tax is of 75$ per ton of CO_2 to be gradually introduced within 2030. OECD (2019) shows similar results and highlights that the current level of taxation is far from the optimal level in most of the countries included in the sample.

benefits. In fact, sovereign GBs can provide a high-quality market benchmark, enhance the green segment's liquidity and encourage other issuers to get into this industry.[14]

Issuers could also resort to GBs in order to reach a broader investor base. The space to attract more investors is greater for small countries or countries with little public debt – whose securities have not been widely dispersed in the international financial market – but even for seasoned issuers, such as France, whose GBs issues have shown a large and diversified turnout. Moreover, a large share of GB underwriters are real money investors, such as pension funds, sovereign funds and insurance companies.[15] Generally, these investors have a long run perspective and, given their common buy-and-hold strategy, they contribute to lower the volatility of these assets in the secondary market. These investors are often in search for financial assets aligned to the green investment strategies they themselves have adopted in recent years. GBs lower the cost of their search, which – from the issuer standpoint – might turn into lower yields at issue. Indeed, thanks to a massive demand and broad investor base, GBs could in principle show a positive price performance in primary and secondary market compared to benchmark indexes and conventional peers (Ridley, Barnshaw 2019). However, the empirical evidence is still controversial.[16]

Sovereign GBs are generally issued on the long-end segment of the yield curve. In case there is no substitution effect with the demand of other extra-long securities from the same issuer, GBs can increase the average maturity of the outstanding debt, thus lowering the refinancing risk. This benefit is greater for emerging or less-developed countries that in general have a less stable demand for extra-long maturities.[17]

Beyond the financial aspects, the most important benefit for GB issuers is reputational. GBs issuance is a concrete indication of the government's long run commitment to a green strategy and a catalyser of the private investments towards green sectors. A GB can therefore be useful in promoting the public green agenda and could be perceived as a sign of a policy shift.[18] The reputation effect could also generate a '*halo effect*' whereby first time GB issuers see their curve of existing (non-green) bonds outperform. This first GB issuance could indeed be seen by ESG focused investors who run green fund as a signal that the entity issuing the bond is transitioning to green. If this were the case, then issuing a GB might lead to a positive performance in this issuing entity's whole existing non green curve (HSBC 2018).

As regards the use of proceeds, the available evidence shows that sovereign GBs are likely to be deployed to a more diverse array of eligible projects than corporate ones. It is difficult to assess if public issuances represent a real increased amount of financing going into public climate-related investment or if these investments may just have been relabelled and repackaged as GBs rather than as traditional bonds (IMF 2016a, 2016b). However the multiplicity of green public investment projects is beneficial, as it allows green investors to diversify their exposure away from renewable energy and energy efficiency projects, and provides a guideline for other issuers to consider financing a broader set of environmental projects.

All these financial and non-financial benefits need to be weighed against potential limiting factors. The issuance and ongoing costs associated with a GB are greater than those of a regular bond. These costs include additional tracking, monitoring, and reporting processes, as well as up-front investment to define the bond's green criteria and sustainability objectives. Even if these extra costs are not particularly high, in the end, they can be transferred to investors.

[14] See OECD 2017 for a complete list of pros and cons for issuers and investors.
[15] See Section 5 for details.
[16] See Section 6 for details.
[17] The little empirical evidence shows that in the year of the launch of the GB, the Sovereigns issued few extra-long securities.
[18] The French GB issuance for instance strengthened the role of Paris as an international hub of sustainable finance.

Additional and more consistent financial and reputational costs could arise in case investors seek penalties for a green default, whereby a bond is paid in full but the issuer breaks agreed green clauses because he is not able to successfully carry out the planned green projects or to provide concrete environmental benefits. These clauses would be triggered even in case of partial or total redemption of the bond, because they are not linked to the issuer's financial obligation (KPMG 2015).

One of the main concerns of sovereign debt managers is the effect of the launch of a GB on existing debt. The introduction of a new kind of bond can determine a trade-off, especially for countries with modest expected funding needs. By adding a new kind of bond to the existing issuance programme, the number of bond lines would increase and the volumes of each of them would decrease. This situation may imply a loss of liquidity for each bond and thus result in a funding cost increase for the issuers. Conversely, if one of the existing bond line (more likely one of the securities in the long-end segment of the yield curve) is replaced with GBs, the loss of liquidity would be minimised only with enough annual green expenditures to ensure that the new bond can be issued up to sufficient volumes. However, planning sizeable green expenditures in the medium term may be difficult for small countries. A theoretical solution to this trade-off has been recently proposed by Denmark and a new issue mechanism was introduced by Germany (the German "*Twin model*").[19]

Innovative, unconventional issue approaches such as the German one seem to be necessary for established sovereign issuers that aim to build a green yield curve along the conventional one, a goal that relies on considerable projected expenditures and requires frequent market taps. This explains why for the time being the vast majority of issuers have opted for a single maturity issuance programme.

Organisational structures set up to manage GB programmes require effective collaboration across multiple stakeholders, underlining the importance of a strong support from the executive leadership. The search for green projects and the need to track the collected funds imply a strong coordination between multiple ministries, departments, and external institutions. At times, this could be very difficult due to the different communication or management practices of the institutions that are in charge of the project side (typically the Ministry of Environment) and those of the financial side (typically the Ministry of Finance).

The intricacies of central government financing, such as intergovernmental fiscal transfers, make it also difficult to ensure effective segregation and tracking of GB proceeds. This is particularly true in low income economies where concerns over transparency and accountability of public finances are typically more acute. Nevertheless, despite the budgetary complexities of public finances, sovereign issuers are taking steps to manage GB proceeds effectively in a variety of ways, including enacting legislation to ring-fence funds and committing to independent audits by external parties.[20]

5. Experiences with green sovereign issuances

At the end of 2020 the sovereign GB market accounted for nearly EUR 73 billion, issued by fourteen countries (Fig. 3). Global sovereign GBs account for only 1.5% of the outstanding debt issued by green sovereign issuers, but the share is growing quickly. Eurozone EUR 61 billion issues represent 83% of the market (90% if European non-Eurozone issues are included). Unsurprisingly, most issues (94%) are euro-denominated while a minority (5%) are denominated in US dollars.

Poland and France pioneered the market between 2016 and early 2017, followed – although with modest issues in absolute terms – by Fiji and Nigeria. In 2018 Belgium, Ireland, Indonesia, Lithuania and Seychelles launched their first GB. In 2019 the Netherlands and Chile entered the segment,

[19] See the Appendix for details.

[20] Poland for instance approved an amendment to the Polish Public Finance Act, reinforcing the issuer's commitment to effective proceeds management. The governments of Belgium, Fiji and France have also committed to independent audits by external parties on the use of proceeds.

followed by Hungary, Sweden and Germany in 2020. Poland and Chile have issued respectively three and four GBs, making them the most prolific issuers among Sovereigns. The French OAT is the largest single sovereign GB having been tapped ten times, reaching EUR 27.7 billion (Table 1).

In some advanced economies, such as France, sovereign green issues seem to have followed the development of the corporate segment, which took the first steps before 2016. The opposite is true for some emerging economies, such as Chile and Indonesia, where sovereign green issues are expected to foster the growth of the rising corporate green finance.

Outstanding sovereign GBs have almost exactly the same terms and conditions of regular bonds. The tenor of most sovereign GBs is higher than 10 years (Fig. 4). The average maturity at issue for the sovereign market is 14 years, sensibly higher than the average maturity of global sovereign issues (6.7 years). This is not surprising, as most of the targets of green projects require several years to be achieved. Only part of the bonds issued by Poland and Chile had a 30-years tenor.

As in the case of regular bonds, the first tranche of sovereign GBs is commonly larger than the following ones (EUR 4 billion on average for European countries) and is issued by syndication in order to benefit from a better pricing. The following tranches are usually issued by auction and tapped until the outstanding amount guarantees a sufficient degree of liquidity. The large majority of sovereign GBs is strippable.

On average GBs issues attracted a higher demand than conventional equivalents and reached a broader investor base. Anecdotally, France communicated that 200 names are included in their green sovereign book, compared with an average of 100 names for ordinary bonds (AFT 2017a, 2017b, 2018a, 2018b). Ireland reported that green investors received more than half of the total amount issued. 41% of Poland's 2026 GB was allocated to green investors; it was 61% for Poland's 2021 GB. The Dutch Treasury Agency gave priority allocation to real money bidders willing to formally declare their green credentials;[21] 29% of the bond was allocated to this kind of investors (DSTA 2018 and CBI 2019a, 2019b).

The four major GB issues are the French, Dutch, Belgian and German ones. Together they represent more than 75% of the market. At the same time of the launch of the green security, these countries issued their GB framework, which included projected green expenditures and supporting legal documentation. Their issuing procedures followed ICMA's principles. ESG rating firms, namely Sustainalytics, Vigeo Eiris and ISS ESG, provided the second party opinion.

The four inaugural issuances saw a strong participation of real money investors: mainly asset managers, pension funds and insurances (Fig. 5). Given the long-term interest of these players, this was somewhat predictable. The French issue showed also a strong presence of banks, which were significantly active in the Dutch, Belgian and German cases as well. A high share of the Belgian placement was allotted to official institutions. Hedge funds participated to all four operations, with a higher presence in the Dutch issue.

The large majority of the investors who took part in the operations were European: investors from Germany, the Netherlands and northern countries were the most active among them. In the French and Dutch placements, domestic investors obtained nearly one third of the issue. UK accounts were significantly present as well, especially in the French and German syndications. Overall, the three operations involved a remarkably diversified set of investors.

The funds raised with GBs have been used differently across countries (Fig. 6).[22] France spent the proceeds on a more diversified set of activities, mainly in the building and living resources sectors,

[21] Investors were invited to certify that they met some specific criteria formulated by the Dutch Treasury Agency. Prior to the auction, 32 investors were registered as green investors and could benefit from priority allocation over other real money investors. Priority allocation could be as much as 10% of their bids at the cut-off spread.

[22] Eligible green expenditures for Germany have been identified in the 2019 budget; however information about the final use of proceeds is not yet available as the first issuance was completed in September 2020.

followed by transport, energy and adaptation to climate changes. Belgium and, to a lesser extent, the Netherlands, instead, allocated a higher share of their funds to the transport sector. Eligible green projects in the three countries were selected through an inter-ministerial coordination. Both internal and external auditors were involved in the process to perform a verification of expenditures. Once expenditures are verified, annual allocation reports are released. France and Belgium publish also a performance report to detail the outputs of their spending (e.g. the number of households benefiting from tax credits for retrofitting their housing or air quality indices). The Netherlands publishes an impact report to assess the ex-post effectiveness of the measures adopted (e.g. quantifying the avoided emission of greenhouse gases or the preserved land areas and water volumes with rich biodiversity).

Sovereign GB sales are rising: according to a survey among debt managers, several sovereign States are expected to begin issuing GBs in the near future (OECD 2017, 2018). Measures to level the playing field, in particular the ongoing works on EU Green Bond Standards, could promote an acceleration in sovereign issues. Some European Sovereigns that have not yet issued GBs indicated that one of the main impeding factor is the uncertainty surrounding the timing and exact content of the EU Green Bond Standards. At the time of writing, Mexico has started its roadshow. Colombia, Denmark, Hungary, Italy,[23] Kenya, and Peru have indicated their intention to issue GBs in 2021. The European Commission is exploring the possibility to issue GBs in 2021/22: its President announced that 30% of the €750 billion 'Next Generation EU' budget will be raised through GBs, making this institution the first worldwide issuer of green securities.[24] Nevertheless, in some jurisdictions the process might slow down because of legal frameworks preventing the constraint of use of public debt.

6. The financial performance of sovereign green bonds

From here on, for the sake of simplicity, we will refer to a positive (negative) yield spread when the yield of the GB is higher (lower) than the yield of a comparable conventional bond.[25]

Theoretically, GBs and their non-green peers are subject to the same market dynamics, so there is no reason why greenness should impact the bond's price. Indeed, a different pricing may not be justified in terms of credit risk. The issuer's balance sheet is the same for a green and a non-GB. Even if an investor considers the credit risk of a GB issuer lower due to its more sustainable business model with more green activities and green assets, this applies equally to a non-GB bond of the same issuer.

However, there are some aspects that could lead to pricing differences. First, GBs performance could be supported by the existence of a specific investors' base, more sensitive to the 'green factor' that can determine excess demand relative to the volume issued (scarcity effect). Second, within the investor base, the presence of institutional, long-term oriented and buy-and-hold investors may be more relevant, making GBs less volatile than their non-green peers in times of risk aversion. On the other hand, considering that GBs are typically issued with a smaller size compared to conventional bonds, price differences may also reflect a different degree of liquidity (the universe of GBs remains still small compared with the total bond universe and in spite of the exponential surge in investor demand for green assets over the past years). Anyway on the back of the prevailing literature, currently there is no clear evidence to suggest that GBs price differently than conventional bonds. The outcomes seem to vary on a case-by-case basis.

[23] The Italian Treasury officially announced the intention to enter the sustainable finance market in its "*Public debt management guidelines for 2021*".

[24] State of the Union Address by President von der Leyen at the European Parliament Plenary, September 2020.

[25] In literature, when the spread between the yield to maturity (or other measures of return such as the Z-spreads) of green and non-green securities is negative, this is defined as "greenium".

Literature review

The existing literature on the yield spread (i.e greenium) tends to compare GB yields with those of a similar conventional bond from the same issuer (Table 2). Most studies are based on multiple-issuer and multicurrency samples; only a few research is focused on sovereign issuers (Intesa 2020, Barclays 2020).

Pioneering research documented the existence of a significant negative yield spread. Ehlers and Packer (2017) studied a sample of 21 GBs using a matching procedure and found a substantial spread of -18 bps in the primary market, which was negligible in the secondary market. Gianfrate and Peri (2018) came to the same result by applying a propensity score matching to 121 GBs issuances. Fatica *et al.* (2018) regressed the issue returns of more than 268 thousand securities over a green dummy and a vector of bond characteristics to find that GBs are issued on average with a -44 bps yield spread. Following a similar approach Kapraun and Scheins (2019) analyzed a sample of more than 1.5 thousand GBs finding that green assets issued by governments or supranational entities, denominated in EUR or USD, exhibit lower yields than their conventional counterparts on both the primary and the secondary market (with a spread of -31 and -3 bps respectively).

Other studies confirm the presence of a negative yield spread, but with a lower size. Zerbib (2019) compared the yields of green and synthetic conventional bonds to observe whether investors pay a premium to get green assets. He found a spread of -8 bps after analyzing 135 worldwide investment grade GBs in the secondary market. Fender *et al.* (2019) adapted the matching approach to securities indexes and found a spread of -3 bps for EUR-denominated assets, which narrowed over time. HSBC (2019) found some evidence of GBs being issued tighter than comparable non green peers. The same analysis, consisting in measuring issue spreads over interpolated curves, however, did not show any significant differential in the secondary market (Kini 2020a, 2020b). Following the procedure previously proposed by Zerbib (2019), Bachelet *et al.* (2019) collected a sample of 89 green and conventional bond couples in the secondary market; they found that GBs have lower yields, of around -3 bps, than their closest brown correspondents only when issued by public institutions. CBI (2019a, 2019b) conducted an extensive analysis on the primary market by comparing 51 GBs' yields on their issue date with theoretical yields obtained by interpolation on the same issuers' curves. 25% of GBs showed an – although almost negligible – negative spread; 45% of GBs priced on their curves. In the secondary market the study was run over 110 green securities and reported that one week after pricing in the primary market, around 50% of the GBs tightened more than their comparable conventional peers; this value rose to 58% one month after the issue.

More recent studies provide mixed evidence. Intesa Sanpaolo (2020) tracked the z-spread difference between European sovereign green and conventional bonds with similar maturity to find a secondary market yield spread between -3 and -1 bps. Analysis by Morgan Stanley (2020) over 28 USD-denominated investment grade securities suggests that in the primary market GBs are even priced with positive spreads; in the secondary market the distinction between GBs and the rest of an issuer's curve was negligible. A secondary market research conducted by Barclays (2020) on green and conventional bonds asset swap spreads showed EUR-denominated GBs issued by supranational institutions and corporates trading tighter than non-GBs, although with a modest differential. Sovereign green securities instead appeared to trade in line with non-green counterparts, probably signaling that in this market segment supply has outpaced the demand from dedicated GB buyers.

With the aim to contribute to the empirical research about the greenium, we investigate the performance of sovereign GBs both in the primary and the secondary market. Specifically, we tackle the following questions: is there a price advantage for sovereign issuers in issuing GBs? Do sovereign GBs outperform their non-green peers? Are GBs more resilient in periods of financial stress?

Primary market

In order to answer the first question we investigate the price at issuance. We have collected data on Refinitiv's Thomson Reuters Eikon regarding all the sovereign GBs issued between end-2016 and 2020. As shown in Table 3 the data encompass GBs from 14 countries, mainly European, including the first issues and the following tranches as well. In order to check the existence of a yield differential we adopt the same approach employed by CBI (2019a, 2019b) in its periodic reports on pricing that basically consists in assessing whether a GB has been issued with a yield greater, lower or in line with the issuer's curve. We compare the yield at issuance of the GBs in the primary market with the yield of a fitted non-green security from the same issuer. This benchmark yield is built by linear interpolation of the secondary market yields observed on the issue date of the GB. The interpolation is performed among the most similar bonds on the issuer's curve based on their residual maturity. The selected non-GBs have a sufficiently high outstanding amount and share the same features of their respective GB (credit rating, payment rank and currency of denomination) except the use of proceeds, which is not green. The resulting benchmark is a proxy of the yield to maturity achievable at the time in which the GB was issued. Since often GBs are issued on the very long-end segment of the yield curve, for some countries it is not possible to find a close conventional non-GB in term of residual maturity; these cases have been excluded from the analysis. Another restriction is imposed on the currency of denomination: we only include in the sample Euro and US Dollar denominated bonds in order to capture the most liquid part of the market. The resulting number of observations is 38 for 10 countries.

The analysis provides mixed results. In 9 cases we find a negative yield spread at issue, while for the other 29 observations the GB's yield at issue is equal or higher than the benchmark yield. The average value of the spread over the whole set of observations is 3.8 basis points and is statistically significant (Table 3). If we restrict the focus to the countries that frequently tapped their GBs, France's GB initially had a positive spread that gradually declined, eventually becoming negative; in the case of the Netherlands the spread is always positive, whereas the outcome for Belgium is volatile. When analysing all the GBs issues from a chronological perspective we see a progressive decline of the yield spread (Fig. 7).

The literature suggests that the yield differential is essentially due to the effect on GBs' yields of ESG investors' research for a green label that turns into an excessive demand of green securities, relatively to the supply of these assets (Ridley, Barnshaw 2019). At the same time, however, the liquidity of the GBs differs from the liquidity of the conventional bonds. The GBs are issued only if there is enough public green expenditure to be financed, so this turns into a lower outstanding amount. The floating share of these securities is also lower, given that a considerable portion of their subscribers adopt 'buy and hold' strategies. This aspect may bring GBs' investors to ask for an 'illiquidity' premium that could contribute to driving up the positive spread. Therefore, we check the existence of a link between the degree of liquidity of GBs and their yield spreads relatively to conventional bonds. We analyse the average spread per GB and a proxy of its liquidity, measured by the average ratio between the GB's outstanding amount and the outstanding amount of the closer non-GB (Fig. 8). The result shows a negative, even if modest, relation between the two variables.

In conclusion, our findings are consistent with the most recent literature, pointing out that in the primary market sovereign GBs are on average slightly more expensive for issuers than their peers. Our analysis also indicates that the lower performance over conventional bonds may be the sign of poorer liquidity conditions.

However, our results are based on a limited number of observations picturing the outcomes of 38 GBs' issuances that significantly differ under two profiles: the issue frequency and technique. Only France, the Netherlands, Belgium and Ireland re-opened their GBs for significant amounts (for these countries we have extended the analysis on the secondary market; see below), while the remaining countries issued a single-tap bond whose novelty may have somehow affected the yield at issue. Concerning the issue technique, there are some structural differences mainly due to the auction cycles

and overbidding that should be considered when comparing primary and secondary market yields (Duffie 2010, Beetsma *et al.* 2016; Sigaux 2018). Some GBs have been issued by auction, while others by bank syndications. This diversity – which splits the dataset into two subsamples, each with a poor number of observations – does not allow to clean the yield spreads from these effects. These caveats highlight the need to let the market expand further before coming to a definitive judgement about the existence of the greenium in the primary market.

Secondary market

Looking at the secondary market performance, given that the GB market is still in its infancy and thus extensive track records are not available, isolating the impact of the green label on the overall pricing outcome is particularly challenging. Furthermore, there are a number of other factors that currently constrain market analysis. First, the lack of transparency on bond market flows: as long as bond markets employ radical transparency technology, the information observable from pricing remains limited.[26] Secondly, the lack of "comparables" (bonds with same characteristics): with the recent exception of Germany, which issued its first GB applying a "*twin model"* scheme, issuers typically do not launch a GB and a non-green equivalent simultaneously.

In order to capture the most liquid and traded portion of the GBs market we restrict the secondary market analysis to the four major sovereign issuers of GBs in the Euro-zone, namely France, Belgium, the Netherlands and Ireland. Germany has not been included due to the early age of its GBs (the first was issued in September 2020). At first glance, a comparison of market valuations shows that GBs seem to trade basically in line with conventional bonds on the issuer's curve (Fig. 9). Yields to maturity for all these countries remained relatively stable since the issuance, moving pretty in line with respect to their closest conventional bonds (Fig. 10). Despite market valuations seem to be fairly aligned, GBs look broadly less liquid vs their conventional peers. GBs' bid-ask spreads are on average between 1.5 and 2 bps compared to 0.5-0.8 bps for their non-green equivalent (Fig. 11). As stated above, this might be mainly attributable to the smaller outstanding amounts of GBs and the lower liquidity, which could theoretically affect GBs attractiveness and market performance.

Although looking at yield to maturity is a simple exercise, this may not lead to accurate results, also considering that the duration of the GBs are in most cases even greater of the immediately longer dated conventional bonds. A more sophisticated approach, increasingly used by practitioners, is to look at the Z-spreads adjusted for the residual maturity. Indeed, by pointing at the zero coupon spreads we basically compare market performance isolating the duration effect.[27] Therefore, as for the primary market, we build a synthetic conventional bond by selecting the two conventional bonds with the closest maturity from the same issuer, having exactly the same characteristics (credit rating, payment rank and currency of denomination) except the use of proceeds, which is not green. We then linearly interpolate the two conventional bonds' Z-spreads at the GB maturity date to obtain a synthetic conventional bond Z-spread.

So let $ZS\_GB_{i,t}$ and $ZS\_CB_{i,t}$ be the GB and the synthetic conventional bond i's Z-spreads on day t . We then define:

$$DZS_{i,t} = ZS\_GB_{i,t} - ZS\_CB_{i,t}.$$

If $DZS < 0$, the spread is negative and is therefore a greenium.

The analysis shows the presence of a tiny negative *DZS* of around 0.5 bps on average (Fig. 12 and 13). This evidence confirms a general convergence of market valuations between green and conventional bonds. Indeed, even looking at the evolution of *DZS*s during the recent Covid-crisis, it is also notable how during sell-off episodes (March-April 2020), GBs traded almost in line with the

[26] Except for a limited portion of the market, data on traded volumes and exchanged prices are not available (the analysis is based on indicative quotes reported by main information providers).
[27] On the zero coupon yield-curve, duration is equal to the residual maturity.

non-green securities. The delta Z-spreads indeed moved in a very tight range for all the period (Fig. 14).

Considering the small size of the greenium resulting from the *DZS* descriptive statistics and the ample difference in bid-ask spreads between green and conventional bonds, we then moved on with an empirical analysis focusing on liquidity. We apply the method primarily used in the literature (Zerbib 2019 among others), which aims at estimating the premium (in terms of yield to maturity or – in our case – Z-spread differential) of a GB over a conventional bond after controlling for the difference in liquidity. We assume that the role of other, potentially relevant, factors may be negligible in explaining Z-spread differentials, considering that the analysis already compares bonds from the same issuer, with the closest maturity and while accounting for differences in the bond structure; the overall sample also includes homogeneous bonds in terms of credit rating (Table 4).

Selecting a congruent measure of liquidity is the main limitation of this approach. This arises from the quality of the data, namely the lack of reliable data on traded volumes. Additionally, we cannot rely on the same proxy used for the primary market analysis (namely the ratio between the GB's outstanding amount and the outstanding amount of the closer non-GB), because this variable does not frequently change over time. Indeed, following the most widely used approach in the literature (Fong *et al.* 2017), we take the quoted bid-ask spread, which is one of the most widespread proxies for bond liquidity. In practical terms we define a relative liquidity indicator as the difference between the bid-ask spread of the GB (*BAgb*) and the bid-ask spread of the closest conventional bond (*BAclosercb*):

$$Liquidity_{i,t} = BAgb_{i,t} - BAclosercb_{i,t}$$

We run the following regression:

$$DZS_{i,t} = \rho_i + \beta\, Liquidity_{i,t} + \varepsilon_{i,t}$$

where ε is a disturbance term; ρ can therefore be interpreted as the residual yield difference between the GB and the conventional bond. A negative sign is evidence of a greenium. In order to have a balanced dataset, we start the review period on the 20 May 2019, the first date when data are available for the four countries included in the sample (456 days).

The results are reported in Table 5. We start by running a simple OLS regression. Then, based on a Ramsey test, we perform a panel estimate. The Hausman test indicates that the Random-effect estimator is more appropriate than the fixed-effect estimator. To account for heteroscedasticity and serial correlation, we complement the analysis with a robust estimate of the standard errors. The regression shows that the Z-spread differential between GBs and conventional bonds amounts to 0.5 bps. The estimate is statistically significant, even after controlling for bond duration and their difference in liquidity; however, it is basically irrelevant from a practical viewpoint, given its tiny size. We also find that, although small, the liquidity differential has significant explanatory power for the different estimators of the standard errors employed in our analysis. It is interesting to note how for a 1 bp increase in the bid-ask spread differential, there is a 0.896 decrease in the *DZS*. This result is also in line with other works[28] and confirms that, based on current market history, investors are not discouraged by the lower liquidity of GBs. To some extent, this outcome may also suggest the existence of a specific investor base for GBs that is more interested in the green label.

To sum-up, our empirical analysis on the secondary market, in line with the most recent literature, shows that GBs – on average – do not substantially outperform their non-green counterparts, so even in periods of financial stress. Although GBs tend to be less liquid, reasonably as a consequence of the smaller size of their outstanding, apparently this does not represent an argument for investors. However, considering the limited time-horizon of the analysis and the restricted sample of

[28] Zerbib (2019), with a regression over a wider universe of corporate and government GBs, find that a 1bp increase in the bid-ask differential induces a 9.88bps decrease in the yield differential (GB vs conventional); similar evidences are also obtained in Bachelet *et al.* (2019), with respect to GBs issued by the institutional sector.

observations (four countries for records over less than two years) further analyses should be performed as data become available following the development of the market.

7. Conclusion

GBs are efficient financial instruments to steer the transition towards a greener economy. In recent years, the GB market has grown from a small niche to a more liquid and diversified segment, supported also by the issues of firms operating in sectors that typically generate negative environmental externalities.

Nevertheless, the contribution of these bonds to the green transition crucially hinges upon the definition of sustainable investments: this is the reason for the great interest of policy makers on the matter, proven by the recent definition of the European Taxonomy regulation.

The growing issuances from Sovereigns represent a motive force and set the trend for more green debt sales for all market segments. When compared to conventional bonds, GBs exhibit specific additional administrative, legal and marketing burdens, which however do not offset the benefits from the signalling effect they produce. Sovereign GBs, indeed, show a country's long term commitment to reduce the environmental impact of economic activities. This makes clear why more and more countries are issuing this kind of securities.

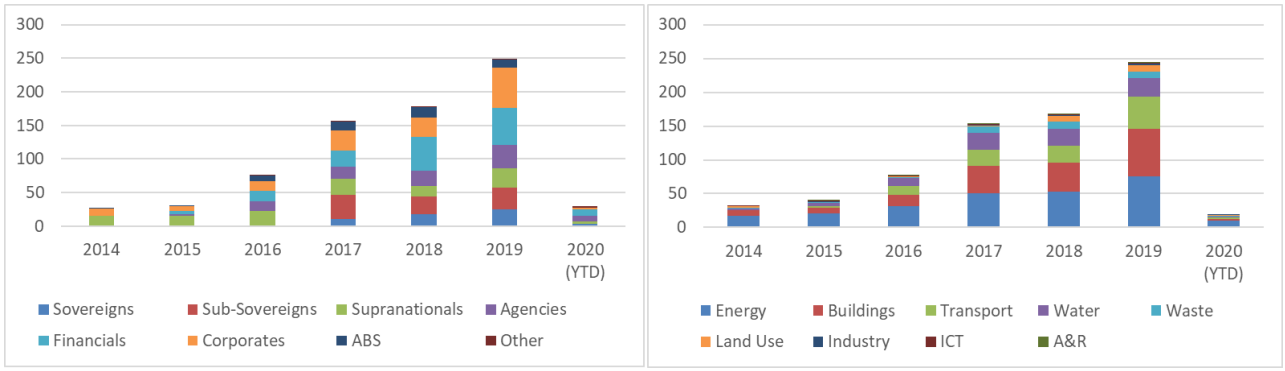
From a financial perspective, the overall GB market is characterized by the activity of many buy-and-hold investors, whose presence still has not hindered the secondary market from functioning well, with GBs priced close to their non-green peers. The increase in issuances made it possible to build sizeable portfolios. Sovereign issues have been successful as they have shown that significant placements are possible without creating distortions on existing debt or difficulties in the pricing mechanism. The approaches recently adopted by some Sovereigns allow to enhance GBs' liquidity without undermining the outstanding conventional bonds' one. This goal is better achievable when the public debt management policy relies on continuous market monitoring and close contact with dealers.

Primary and secondary market analyses do not show the existence of a remarkable and systematic price difference between sovereign green and conventional bonds. The evidence of a greenium (lower yield) would have represented an additional opportunity for issuers and thus a further driver of the sovereign GB market. Nevertheless, the demand of these instruments is solid and green finance remains a mainstream theme. On the other hand, the lack of a clear evidence of a cost advantage should not prevent more Sovereigns from entering the market since the reason for issuing these securities is not just a simple matter of economic convenience. GBs can indeed be extremely useful to manage environmental risks and can play a specific role in solving the intergenerational trade-off in climate mitigation policies.

Figures and Tables

Figure 1

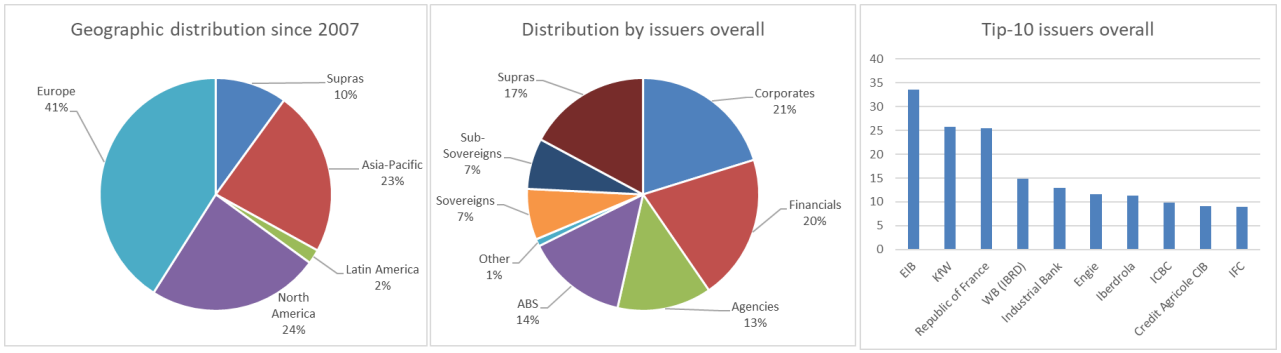
Evolution of GB supply by issuers' sector and use of proceeds (bn USD, as of September 2020)



Source: authors' elaboration on Climate Bonds Initiative data and Dax (2020).

Figure 2

GB market breakdown by country and issuers' type (as of September 2020)

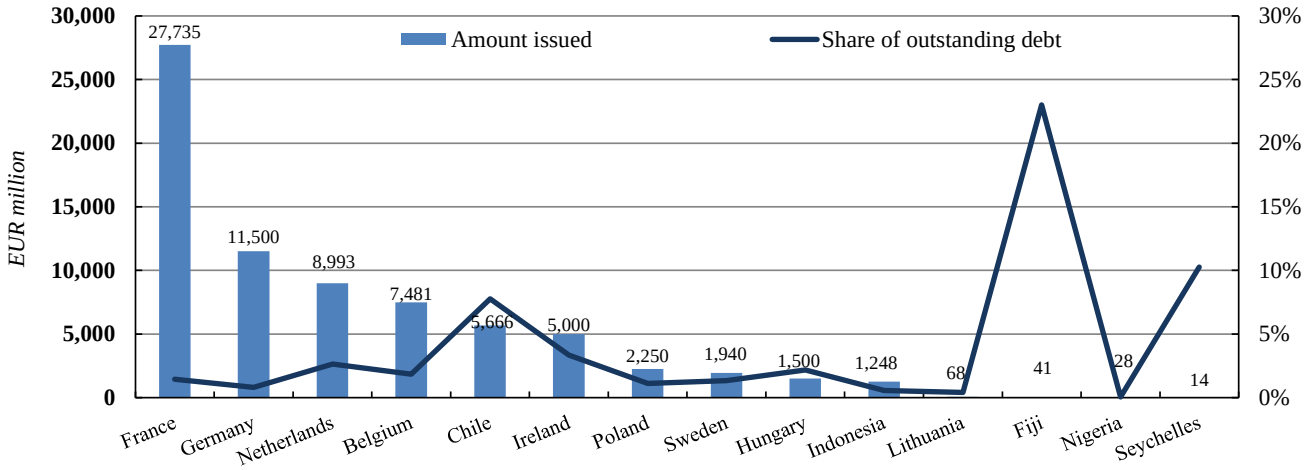


Source: authors' elaboration on Climate Bonds Initiative data and Dax (2020).

Figure 3

Sovereign green bond issues

(EUR million and percentage points)

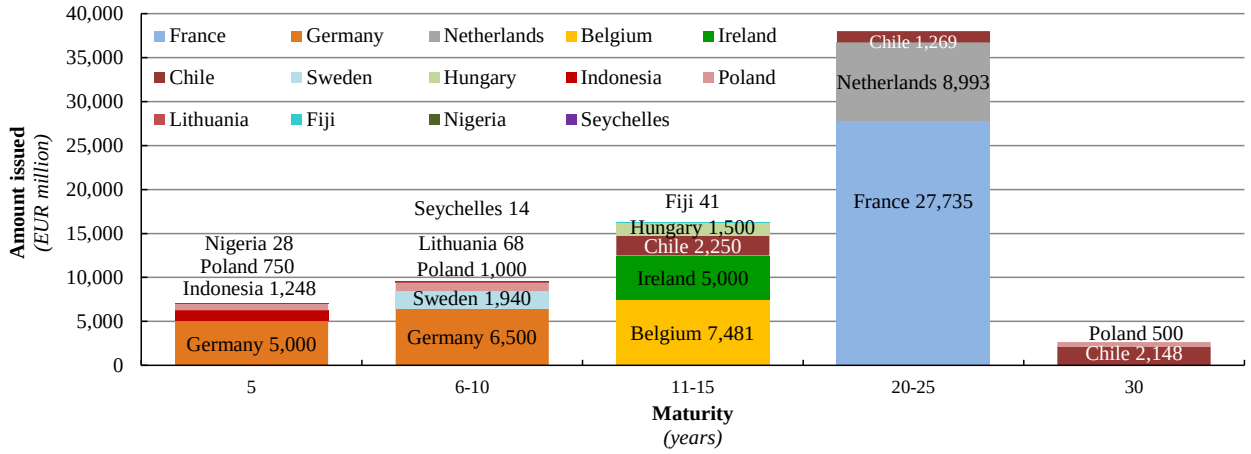


Source: Bloomberg, Refinitiv.

Figure 4

Sovereign green bond issues by tenor

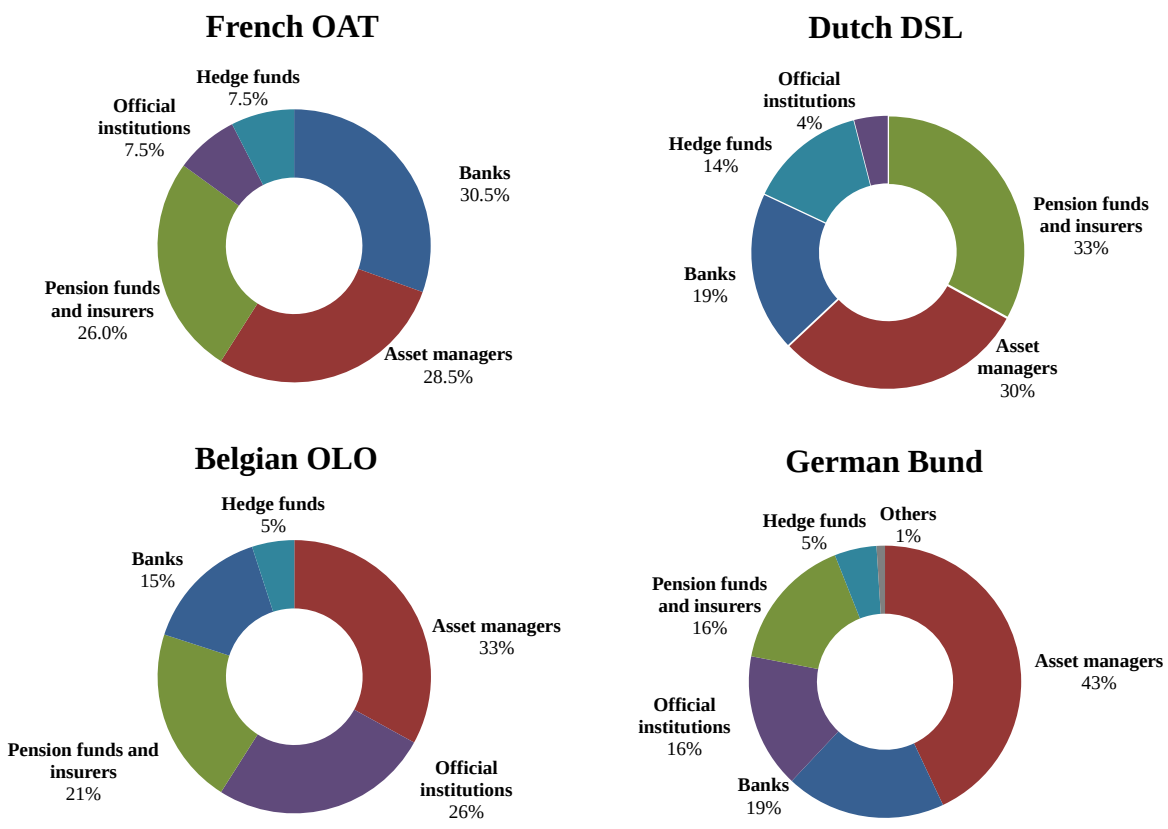
(EUR million)



Source: Bloomberg, Refinitiv.

Figure 5

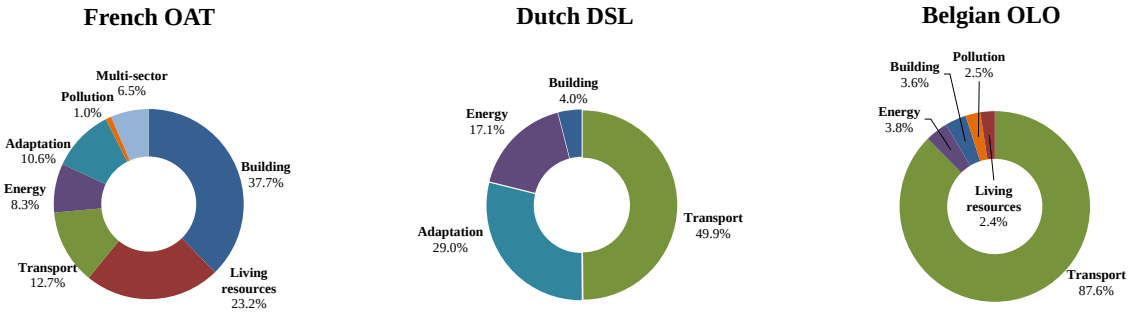
Investor base of the French, Belgian and Dutch first green bond issues



Source: AFT, DSTA, BDA, FRGFA.

Figure 6

Use of proceeds of the French, Belgian and Dutch green bond

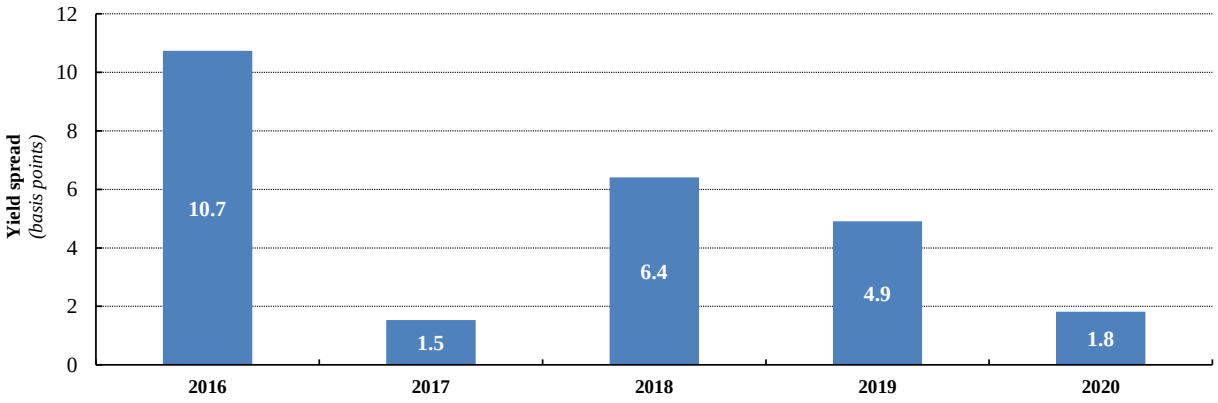


Source: AFT allocation and performance reports for 2017 and for 2018; DSTA report for 2018 and 2019; BDA allocation report for 2017 and 2018.

Figure 7

Average yield spread per year on the primary market

(basis points)

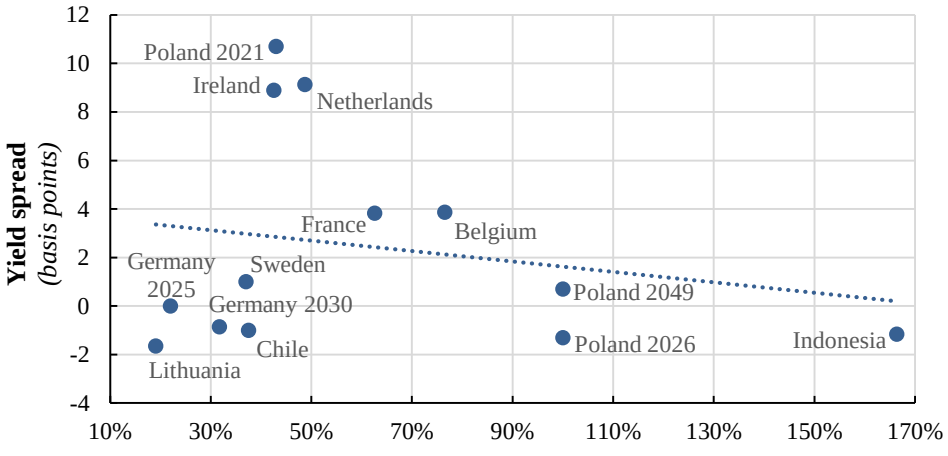


Source: authors' elaboration on Refinitiv data.
Note: yield spread is computed as the difference between the yield at issue of the GB and the yield of the fitted non-green security. The figures are computed as simple average of the yield spread registered over the GB issues in each year.

Figure 8

Average yield spread on the primary market (y-axis) vs average green bond size (x-axis)

(basis points and percentage points)



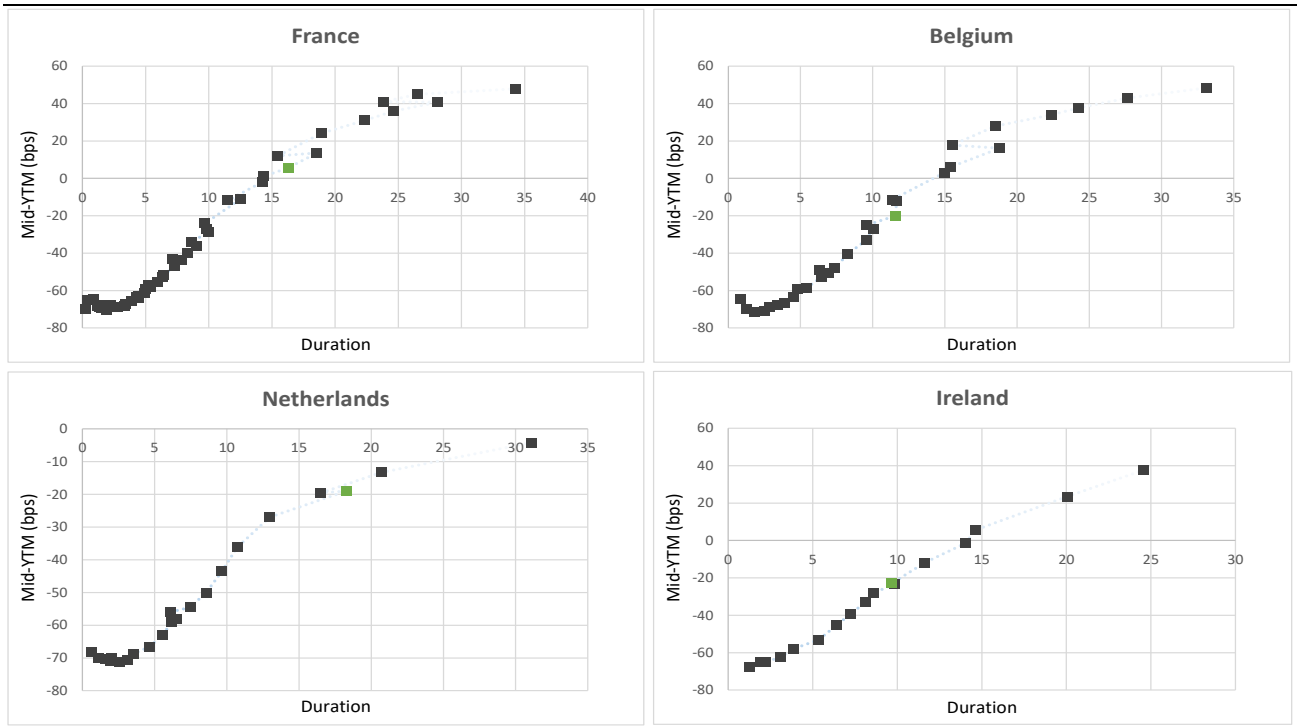
GB size

(ratio between the GB's outstanding amount and the outstanding amount of the closer non-GB)

Source: authors' elaboration on Refinitiv data.
Note: yield spread is computed as the difference between the yield at issue of the GB and the yield of the fitted non-green security. The figure shows average values per green bond over 2016-2020.

Figure 9

Green vs. non-green, market valuation as of December 3, 2020.

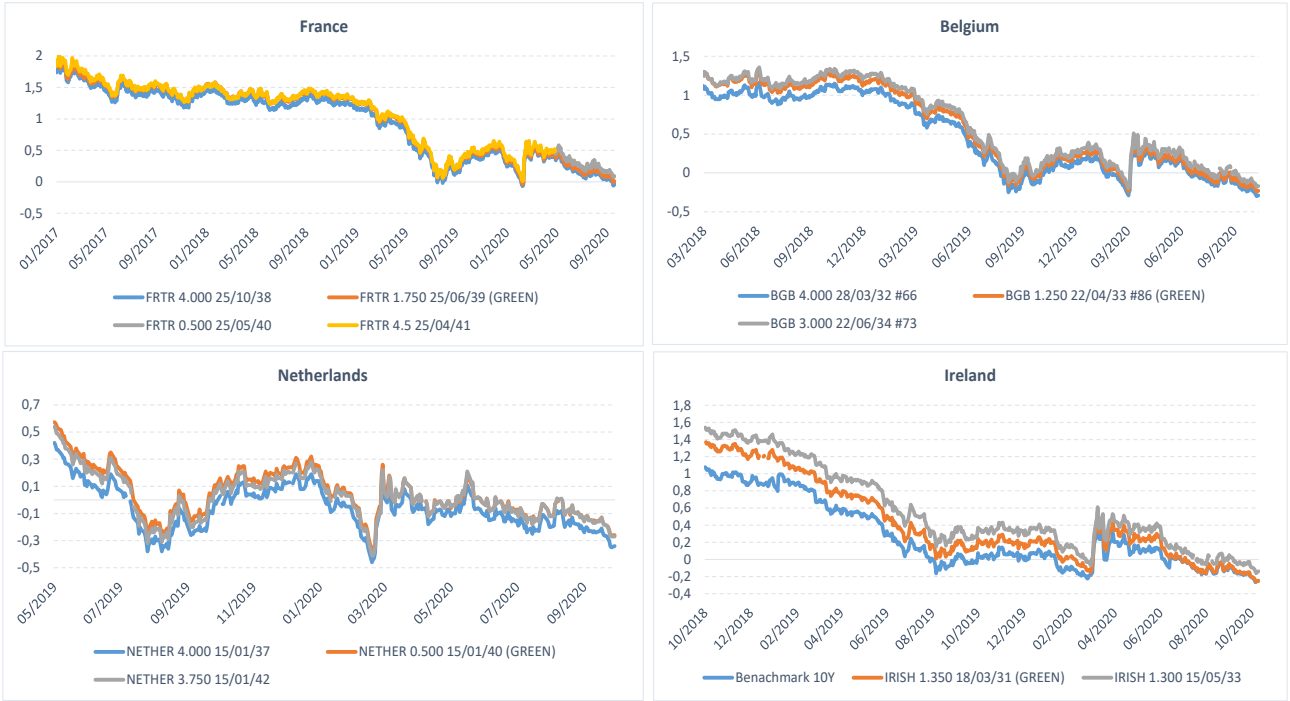


Source: authors' elaboration on Refinitiv data.

Figure 10

Yield to maturity since issuance of selected sovereign green bonds and closest non-green peers

(Percentage points)

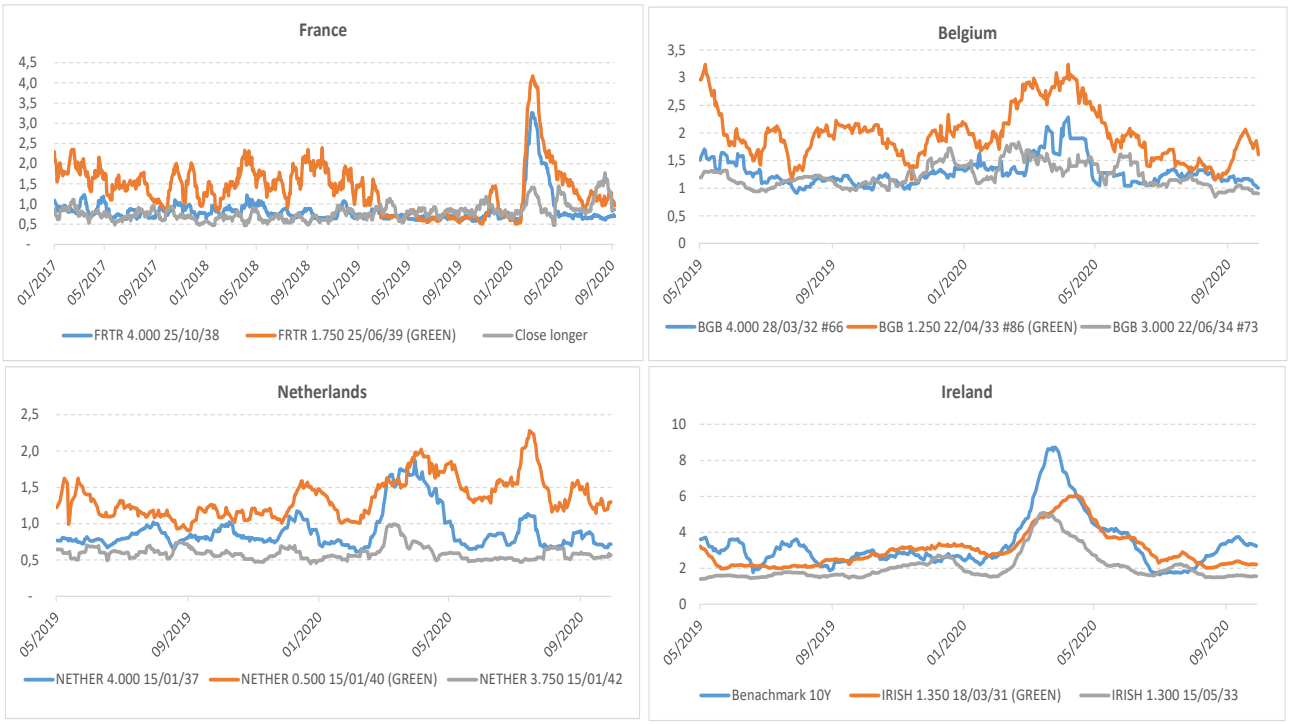


Source: authors' elaboration on Refinitiv data.

Figure 11

Bid-ask spread of selected sovereign green bonds and non-green peers since issuance

(5 days moving average bid-ask spreads, basis points).

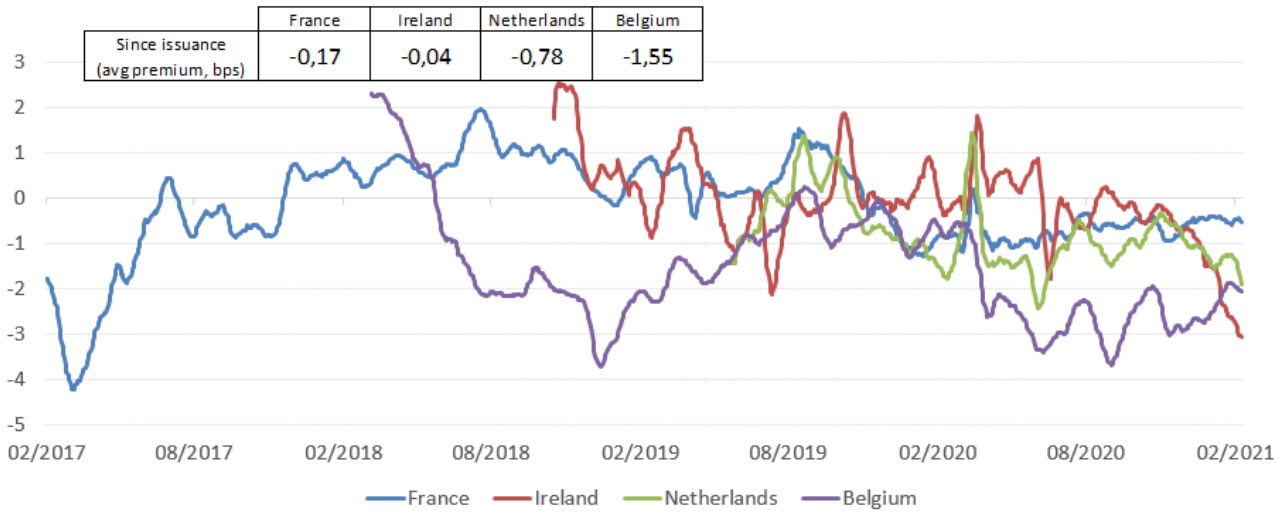


Source: authors' elaboration on Refinitiv data.

Figure 12

Delta Z-Spread since issuance (greenium if <0)

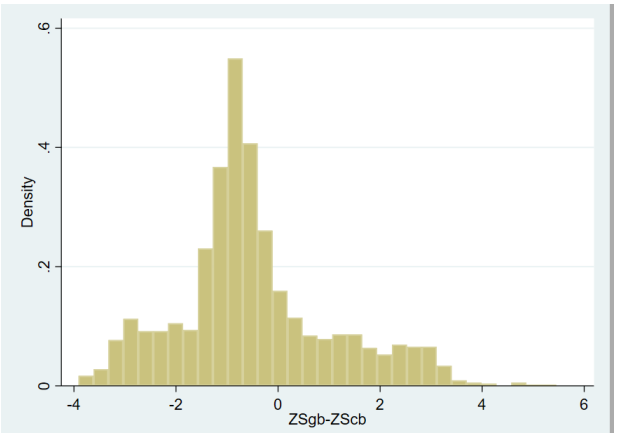
(5 days moving average, basis points).



Source: authors' elaboration on Refinitiv data. Note: delta Z-spread is computed as the difference between the Z-spread of the GB and Z-spread of the synthetic conventional bond.

Figure 13

Delta Z-Spread distribution (greenium if <0)



DZS: descriptive statistics

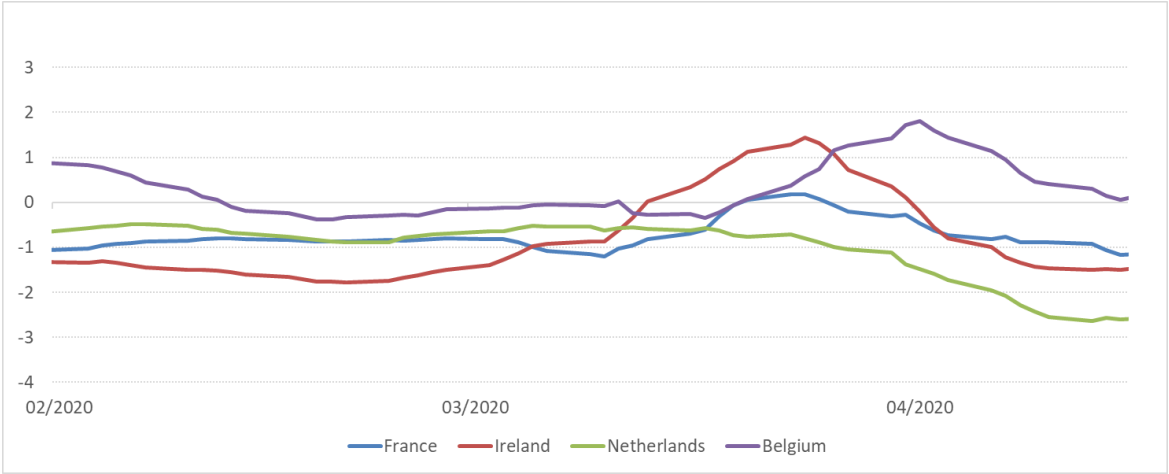
obs	1824		Variance	2.307	
mean	-0.486		Skewness	0.637	
st. dev	1.518		Kurtosis	3.501	
min	-3.91				
max	5.45				
Distribution	10%	25%	50%	75%	90%
	-2.4	-1.26	-0.72	0.11	1.78

Source: authors' elaboration on Refinitiv data. Note: delta Z-spread is computed as the difference between the Z-spread of the GB and Z-spread of the synthetic conventional bond.

Figure 14

Delta Z-Spread (greenium if <0), Covid-19 sell-off focus

(5 days moving average, basis points).



Source: authors' elaboration on Refinitiv data.

Table 1

Sovereign green bond issues

Country	ISIN code	Maturity	Rating (Fitch/Moodys/S&P)	Currency	Coupon rate (%)	Amount oustanding (EUR million)	First issue date	Tranches issued
Belgium	BE0000346552	22/04/2033	AA-/Aa3/AA	Euro	1.250	7,481	05/03/2018	9
Chile	US168863DL94	25/01/2050	A+/A1/AA-	US Dollar	3.500	2,148	25/06/2019	2
Chile	XS1843433639	02/07/2031	A+/A1/AA-	Euro	0.830	1,555	02/07/2019	2
Chile	XS2108987517	29/01/2040	A+/A1/AA-	Euro	1.250	1,269	29/01/2020	1
Chile	US168863DN50	27/01/2032	A+/A1/AA-	US Dollar	2.550	695	27/01/2020	1
Fiji	FJ0406990632	01/11/2030	na/Baa3/BB-	Fiji Dollar	6.300	33	01/11/2017	4
Fiji	FJ0406990624	01/11/2022	na/Baa3/BB-	Fiji Dollar	4.000	8	01/11/2017	1
France	FR0013234333	25/06/2039	AA/Aa2/AA	Euro	1.750	27,735	31/01/2017	11
Germany	DE0001030708	15/08/2030	AAA/Aaa/AAA	Euro	0.000	6,500	09/09/2020	1
Germany	DE0001030716	10/10/2025	AAA/Aaa/AAA	Euro	0.000	5,000	04/11/2020	1
Hungary	XS2181689659	05/06/2035	BBB/Baa3/BBB	Euro	1.750	1,500	05/06/2020	1
Indonesia	US71567RAJ59	01/03/2023	Baa2/BBB/BBB	US Dollar	3.750	1,248	01/03/2018	1
Ireland	IE00BFZRQ242	18/03/2031	A+/A2/AA-	Euro	1.350	5,000	17/10/2018	2
Lithuania	LT0000610305	03/05/2028	A/A3/A+	Euro	1.200	68	03/05/2018	3
Netherlands	NL0013552060	15/01/2040	AAA/Aaa/AAA	Euro	0.500	8,993	23/05/2019	5
Nigeria	NGFGB2022S13	22/12/2022	B/B2/B-	Nigerian Naira	13.480	28	22/12/2017	1
Poland	XS1766612672	07/08/2026	A-/A2/A	Euro	1.125	1,000	07/02/2018	1
Poland	XS1536786939	20/12/2021	A-/A2/A	Euro	0.500	750	13/12/2016	1
Poland	XS1960361720	08/03/2049	A-/A2/A	Euro	2.000	500	07/03/2019	1
Seychelles	XS1885544236	11/10/2028	nd/B+/nd	US Dollar	6.500	14	11/10/2018	1
Sweden	XS2226974504	09/09/2030	AAA/Aaa/AAA	SEK	0.125	1,940	09/09/2020	1

Source: Bloomberg, Refinitiv.

Table 2

Major literature contributions to "greenium" research

Author	Year	Market (primary / secondary)		Evidence of a negative spread (yes / no)	
Bachelet et al.	2019		S		Y**
Barclays	2020		S	Y*	
CBI	2019	P	S	Y*	Y**
Ehlers and Packer	2017	P	S	Y***	N
Fatica et al.	2018	P		Y***	
Fender et al.	2019		S		Y**
Gianfrate and Peri	2018	P		Y***	
HSBC	2019	P	S	Y**	N
Intesa Sanpaolo	2020		S		Y*
Kapraun and Scheins	2019	P	S	Y***	Y*
Morgan Stanley	2020	P	S	Y*	N
Zerbib	2017		S		Y**

**** substantial negative spread; ** lower size negative spread; *almost negligible negative spread.*

Table 3

Primary market analysis

a) Yield spread per country and tranche

(basis points)

Tranche	Belgium	Chile	France	Germany	Indonesia	Ireland	Lithuania	Netherlands	Poland	Sweden	Mean
1	9.4	-1.0	-3.5	-0.4	-1.2	10.0	10.3	11.1	3.4	1.0	**3.9**
2	3.2		2.9			7.8	-8.2	7.6			**2.6**
3	9.2		5.2				-7.0	10.8			**4.6**
4	3.0		5.6					7.7			**5.5**
5	4.6		12.0					8.5			**8.4**
6	4.1		5.6								**4.8**
7	8.4		7.4								**7.9**
8	-9.2		-6.1								**-7.7**
9	2.3		9.4								**5.8**
10			-0.5								**-0.5**
11			4.2								**4.2**
Mean	**3.9**	**-1.0**	**3.8**	**-0.4**	**-1.2**	**8.9**	**-1.6**	**9.1**	**3.4**	**1.0**	**3.8**

Source: authors' elaboration on Refinitiv data.
Note: yield spread is computed as the difference between the yield at issue of the GB and the yield of the fitted non-green security.

b) Yield spread key statistics

(basis points)

Primary market analysis - outcome			
N	*Mean*	*Std. Deviation*	*Std. Error mean*
38	3.784	5.774	0.937
df		37	
t Stat		4.039	
P value		0.000	

Source: authors' elaboration on Refinitiv data.

Table 4

Green and conventional bond credit ratings

ISIN	Description	Issuer Rating
FR0013234333	FRGV 1.750 06/25/39	AA (high)
FR0010773192	FRGV 4.500 04/25/41	AA (high)
FR0010371401	FRGV 4.000 10/25/38	AA (high)
IE00BFZRQ242	IEGV 1.350 03/18/31	A+
IE00BFZRPZ02	IEGV 1.300 05/15/33	A+
GTIE10Y GOVT	IEGV 10/18/31	A+
NL0013552060	NLGV 0.500 01/15/40	AAA
NL0009446418	NLGV 3.750 01/15/42	AAA
NL0000102234	NLGV 4.000 01/15/37	AAA
BE0000346552	BEGV 1.250 04/22/33	AA+
BE0000333428	BEGV 3.000 06/22/34	AA+
BE0000326356	BEGV 4.000 03/28/32	AA+

Note: list of the green and conventional bonds in the sample.

Table 5

Results of the regression: $DZS\ i,t\ =\ \rho\ i\ +\ \beta\ \text{Liquidity}\ i,t + \in i,t$

Where:

$DZS\ i,t = ZS\_GB\ i,t - ZS\_CB\ i,t.$

$Liquidity\ i,t\ =\ BAgb\ i,t - BAclosercb\ i,t$

	OLS	Fixed effects	Random effect GLS	Random effect GLS (robust s.e.)
Constant	-0.465*** (0.285)	-0.471*** (0.027)	-0.471** (0.231)	-0.471* (0.248)
Liquidity	-1.219*** (0.385)	-0.874*** (0.081)	-0.896*** (0.079)	-0.896** (0.424)
Observations	1824	1824	1824	1824
i = 4 (countries)		4	4	4
t = 456 (days)		156	456	456
R2_overall	0.35	0.35	0.35	0.35
R2_within		0.06	0.06	0.06
R2_between		0.87	0.87	0.87
F stat	1000.86			
Prob F stat	0.00			

Note: *p<0.1; **p<0.05; *** p<0.01. St. errors in brackets. Ramsey reset test using powers of the fitted values of dzs. Ho: model has no omitted variables. F(3, 1819) =18.95; Prob > F = 0.0000. Hausman Test: Ho: difference in coefficients not systematic: chi2(1) = (b-B)'[(V_b-V_B)^(-1)](b-B)= 1.47; Prob>chi2 = 0.2254.

Appendix

A1. Green bonds market drivers in the EU

International institutions consider GBs a highly effective tool to reach the global environmental targets. These purposes were placed firmly back on the international agenda in 2015 when governments committed to the Sustainable Development Goals[29] to guide international action on economic, social and environmental targets. At the end of the same year, 195 countries signed the Paris Agreement and thus joined the cause to limit temperature increase to 1.5°C above pre-industrial levels. In order to meet that goal, according to the United Nations, global emissions would need to drop by 7.6% each year between 2020 and 2030 (UN 2019).

Climate change mitigation was soon recognised as a priority also by the European Commission. In 2015 it defined a binding target to lower emissions in the EU by at least 40% of 1990 levels by 2030. At that time the level of environmentally sustainable investments in Europe was very far from this goal: Europe had to close a yearly investment gap of almost EUR 180 billion to achieve EU climate and energy targets by 2030 (EC 2018). A lack of clarity among investors regarding what constitutes a sustainable investment was a contributing factor behind this investment gap. To address the significant amount of investments needed to reach this goal, in March 2018 the Commission proposed an Action Plan for financing sustainable growth. The aim of the plan was to redirect capital flows towards a sustainable economy, therefore encouraging the integration of ESG factors into investment decision making, and to facilitate the mobilisation of private capital to finance sustainable activities (EC 2018). The Action plan was intended not only to transform Europe's economy into a greener, more resilient and circular system but also to boost competitiveness by improving the efficiency of production processes and reducing the costs of accessing and managing resources. It was based upon four key pillars. The first was the establishment of a clear and detailed EU taxonomy to assess the environmental sustainability of an economic activity and therefore define a common language for the participants of the financial system. The second pillar was the definition of EU GB standards for green financial securities that could help investors identify products complying with green criteria. The third was the strengthening of the transparency of companies on their ESG policies to ensure the right information has been provided to investors. The final pillar was the introduction of a ‘green supporting factor’ in the EU prudential rules for banks and insurance companies in order to incorporate climate risks into banks' risk management policies.

To further ease the transition of the European economy to greenness and sustainability, the European Commission launched the European Green Deal in 2019. This is a new growth strategy aimed at transforming the EU into a modern, resource-efficient and competitive economy, with a goal of economic growth decoupled from resource use and with zero net emissions of greenhouse gases in 2050 (EC 2020). The aim of the program is to mobilise private and public sustainable investments for at least one trillion euros over a decade through the EU budget and other associated instruments. Finally, to help repair the economic and social damage brought by the coronavirus pandemic, in May 2020 the European Commission launched a major recovery plan for Europe based on harnessing the full potential of the EU budget. Hence, since 2021 further investments in green real asset will be pursued on a large scale. Besides, a part of these investments will be financed by issuing green securities on financial markets.

The first achievement in the European green strategy was the political agreement on the Taxonomy regulation reached at the end of 2019 by the European Parliament, that will be in effect starting from December 2021. The Taxonomy regulation sets six macro environmental objectives and

[29] The 17 Sustainable Development Goals address the global challenges of the modern world, including those related to poverty, inequality, climate change, environmental degradation, peace and justice.

four requirements that economic activities need to comply with to be qualified as sustainable[30]. Given the high technical complexity involved in the topic, the Commission has set up an expert group on sustainable finance (TEG) to make recommendations concerning the technical screening criteria[31]. These criteria should allow for a more precise and granular set of definitions to determine what economic activities qualify as sustainable. The two delegated acts that will determine the screening criteria for the first two climate-related objectives (i.e. 'Climate Change Mitigation' and 'Climate Change Adaptation') are ready and are set to be adopted by the Commission by the end of 2020; the specification of the four other environmental objectives will follow at a later time.

The Taxonomy Regulation does not require financial market participants to invest in taxonomy-eligible activities but, rather, to disclose information on how and to what extent the taxonomy has been applied to determine the environmental sustainability of the products they offer. Once the Taxonomy Regulation will be fully implemented, it will become a mandatory reference for sustainable financial products in Europe (TEG 2019a, 2019b).

The taxonomy will be also the base for the realization of the second pillar of the EU action plan: the definition of the EU Green Bond Standards. This is a voluntary scheme that issuers can choose to follow when issuing GBs. The EU Green Bond Standards will be similar to the ICMA Green Bond Principles but with some specific features. In particular: the proceeds from a bond issue should be invested in activities consistent with the EU taxonomy; the green projects must respect the 'no significant harm' requirement (do not cause harm to any of the other environmental objectives); the third party certifications should be provided by firms included in a list managed by the European Securities and Markets Authority (ESMA). The EU Green Bond Standards are expected to be issued in 2021.

[30] The macro environmental objectives are as follows: (i) climate change mitigation; (ii) climate change adaptation; (iii) sustainable use and protection of water and marine resources; (iv) transition to a circular economy; (v) pollution prevention and control and (vi) protection and restoration of biodiversity and ecosystems. The four requirements are: (i) providing a substantial contribution to at least one of the six environmental objectives above; (ii) causing 'no significant harm' to any of the other environmental objectives; (iii) complying with robust and science-based technical screening criteria and (iv) complying with minimum social and governance safeguards.

[31] The TEG is composed by 35 members from civil society, academia, business and the finance sector, as well as additional members and observers from EU and international public bodies.

A2. The Danish model for sovereign green bonds

The Danish debt management office (DMO) is working on an innovative model to enable small sovereign issuers access the GBs market without incurring in a liquidity drop of existing bonds and neither being forced to project undesired green expenditures (Danmarks Nationalbank 2020).

The Danish GB would be made of two separate components, as shown below: (i) a traditional government bond and (ii) a green certificate attached to it, signaling a commitment that the proceeds from the sale of that traditional bond will finance expenditures for green projects.

$$Danish\ green\ bond = Traditional\ sovereign\ bond + Green\ certificate$$

In this model the DMO sells a green certificate attached to a traditional government bond. In fact, the DMO will not supplement the current issuance of traditional government bonds with a new GB – as happened by now in the other countries. It will keep on issuing its traditional sovereign bonds, but it will add the green certificate to some placements, to be labelled as 'green auctions'. This mechanism allows the DMO to solve the abovementioned trade-off, even if the participation of green investors, who often adopt a buy-and-hold strategy, may cause a reduction in the free-floating volumes of the securities issued.

Investors will have the opportunity to buy sovereign GBs by purchasing green certificates and their correspondent government bonds, at auctions or in the secondary market. Indeed, green certificates will be securities – technically zero-coupon bonds with zero redemption at maturity and the same tenor of their correspondent traditional bonds – with their own ISIN code, and will be tradable separately in the secondary market.

Since there will be no cash flows connected with the certificates, their value will rely in the greenness they attribute to their correspondent traditional bond. Therefore, Denmark sovereign bond investors will predictably price these certificates exclusively according to their benefits in adding a green label to their investment. A positive price for green certificates could turn into a lower yield at issue for these securities over identical conventional bonds, what is commonly known as 'greenium' (see Section 6).

A3. The German 'twin model' for sovereign green bonds

In September 2020 Germany launched its first GB: a 10-year security issued for EUR 6.5 billion via bank syndication. The inaugural issuance followed the release of the German GB framework, aligned with the most recent ICMA's Green Bonds Principles and compliant with the draft EU Green Bond Standard. This framework states the plan to offer GBs on several maturities, ranging from 2 to 30 years, thus building a green yield curve in the medium term with the ambition to establish benchmarks for the euro green finance market.

German GBs issuance mechanism is based on the twin model, an original approach allowing issuers – at least theoretically – to avoid a liquidity drop in existing bonds and enhance the liquidity of the GB itself at the same time. This need is particularly important for the German DMO, given the bunds' benchmark status for all interest rate products in the euro area (FRGFA 2020).

The model requires that any GB to be issued share the same characteristics of an existing, conventional security; this leads to the creation of twin bonds, identical in maturity and coupon. Their issuance volume, however, is different, with conventional issues being placed at significantly larger volumes than their green twins. They also differ in their ISIN code, so to be traded independently. This allows for a direct measurability of greenium as investors' preference for GBs can be derived directly from market prices. The first German GB became the green twin of the conventional 10-year bund, which had already been issued three times before launching the GB. This inaugural issuance resulted in a primary market yield spread of nearly -1 basis point (see Section 6).

Each GB is issued together with an additional tranche of its conventional twin. In fact, some re-openings originally foreseen for the conventional twin are turned into an auction (or syndicate) for the GB; at the same time, the issuer's own holdings in the conventional twin are increased for an amount that is exactly equal to the issuance amount of the GB. The tap amount of the conventional bond is not meant to be placed in the secondary market; the additional own holdings are to be used on the secondary market for repo transactions or lending activities. The high liquidity of the conventional securities should therefore remain unchanged.

The model demands the issuer to play an active role in the secondary market for the GB as well. The DMO indeed is available for transactions that ensure the liquidity and tradability of the green security. Germany has foreseen debt-neutral sale-and-purchase transactions (‘switch trades’) between twin bonds to be potentially triggered by a drop in the price of a GB relatively to the price of its conventional twin. The DMO plans additional transactions in repos or lending activities to further support the use of the GB as collateral in the interbank market.

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