Green Bonds and Sustainable Environmental Policy

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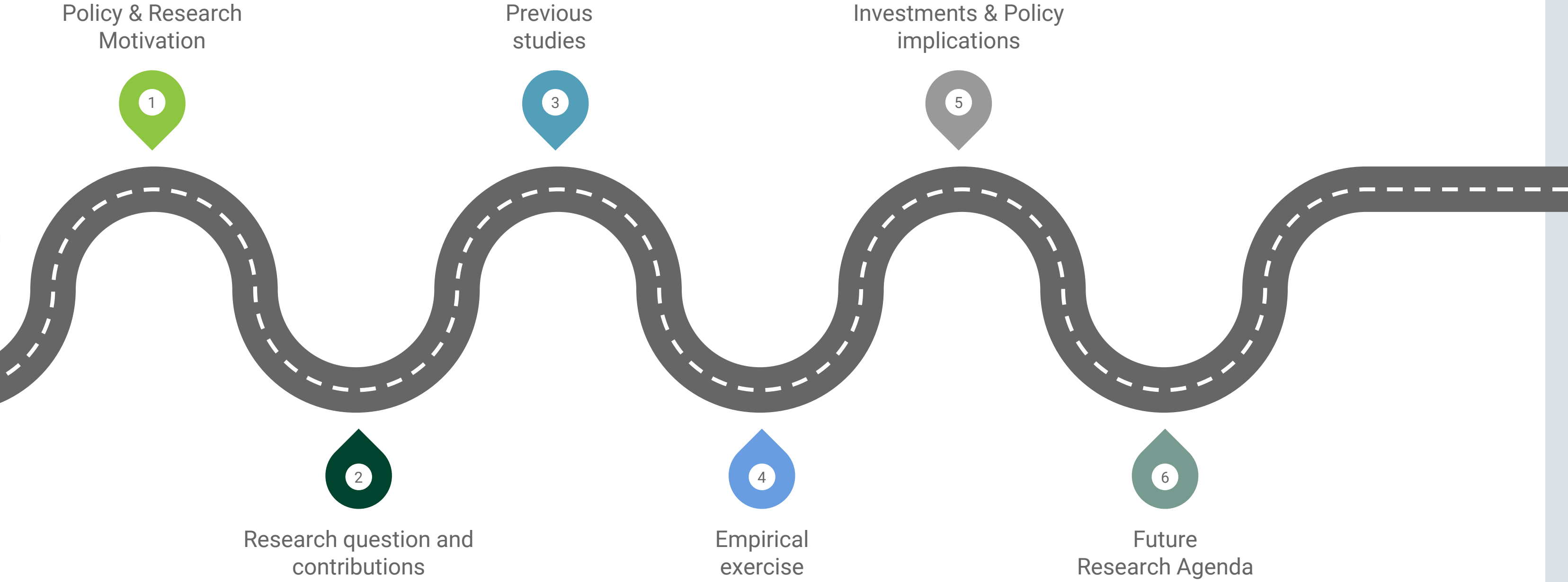
Roadmap



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Let’s start with the motivation and research topic

It is worth highlighting the commitments regarding CO_2 emissions, namely in the Kyoto Agreement and the Paris Agreement.

Following ratification of the first protocol, the largest international carbon market emerged - European Union Emissions Trading System (EU-ETS), which corresponds to a system of ‘cap and trade’, i.e., a system incorporating a limit of allowances decreasing over time (European Environment Agency, 2018).

POLICY & RESEARCH MOTIVATION

From the angle of carbon mitigation, the so-called Sustainable Finance via the green bond market stands out, facilitates the financing of “green” projects or companies (Kochetygova & Jauhari, 2014), lessening the costs of pollution (Ehlers & Packer, 2017), and providing an important vehicle in financing environmental solutions directed to investment in green or low-carbon assets (Climate Bonds Initiative, 2019).

There is a notably limited production of research studies on interactions between the carbon market and “clean” companies’ share market (Kumar, Managi, & Matsuda, 2012; Oestreich & Tsiakas, 2015; Dutta, Bouri, & Noor, 2018), finding greater interest in the relations between clean/renewable share markets and oil prices (Henriques & Sadorsky, 2008; Sadorsky, 2012; Reboredo, 2015; Ahmad, 2017; Ferrer, Shahzad, López, & Jareño, 2018; Paiva, Rivera-Castro, & Andrade, 2018 ; Reboredo & Ugolini, 2018; Pham, 2019), and more recently, between dematerialization and financial performance (Leitão e Ferreira, 2021.b).

GREEN BONDS

are labelled “green” by the issuer, being described in the bond emission document, considering the criteria of the Climate Bonds Initiative.

FLYING IN THE CLOUDS

EU-ETS MARKET

Concerning international finance, carbon markets and financial products such as green bonds have been developed. However, analysis of the carbon market's behaviour has been extended above all in the EU-ETS market, in order to assess the different ways in which the fundamentals influence the prices of CO2 emissions, based on energy commodities.

COMMERCIALIZATION

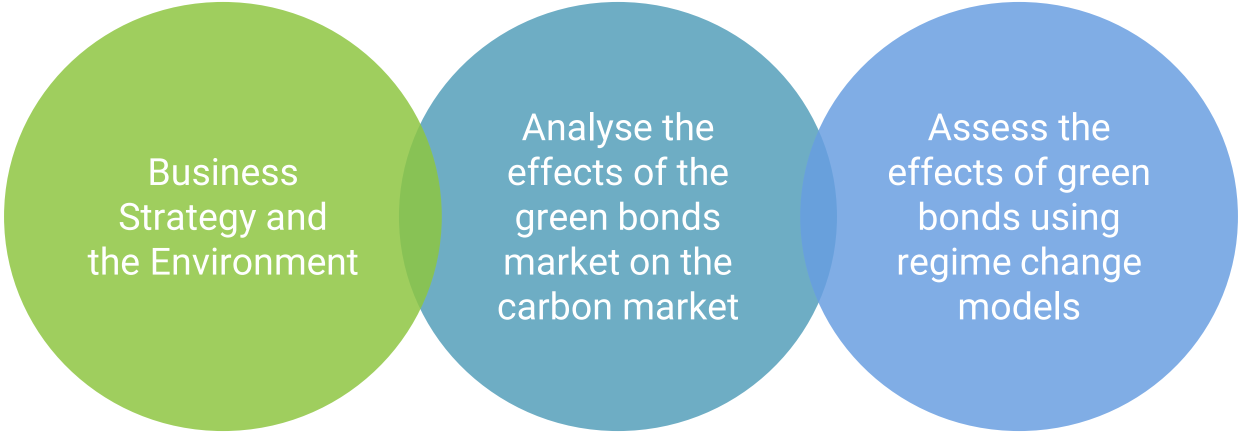
EU-ETS covers Power Stations, Industrial Plants and aviation sectors. In fact, the "commercialization of allowances in EU ETS is carried out in four phases, regarding the periods 2005-2007 (Phase I), 2008-2012 (Phase II), 2013-2020 (Phase III) and 2021-2030 (Phase IV). This led to a securitization of allowances through platforms for negotiating futures, spot, forward and options contracts.

📌 This research aims to determine the dynamics and non-linearities, mainly, of green bond markets, and at the same time, with the conventional bond market and the energy commodities market, in terms of the behavior of the CO_2 emission market, using the Markov-switching econometric methodology and quantile regression models

RESEARCH QUESTION

What are the interactions between the carbon market and "clean" companies' share market?

CONTRIBUTIONS



Leitão, J.; Ferreira, J.; and Santibañez Gonzalez, E. (2021.a). Green bonds, sustainable development and environmental policy in the European Union carbon market. *Business Strategy and the Environment*. Wiley. DOI:10.1002/bse.2733.

PREVIOUS STUDIES

Green bonds performance and investor sentiment

Piñeiro-Chousa, López-Cabarcos, Caby, & Šević, 2021.

Effects of green bonds on companies‘ performance and valorisation

Tang & Zhang, 2019.

Relations with a time variation between green bonds and clean energy stocks

Hammoudeh, Ajmi, & Mokni, 2020;Liu, Liu, Da, Zhang, & Guan, 2021.

Behaviour of green bonds and conventional bonds

Hachenberg & Schiereck, 2018; Gianfrate & Peri, 2019; Broadstock & Cheng, 2019; Bachelet, Becchetti, & Manfredonia, 2019; Zerbib, 2019; Kanamura, 2020.

Determinants of the green bond market’s development

Chiesa & Barua, 2019; Barua & Chiesa, 2019; Tolliver, Keeley, & Managi, 2020.

Conventional bonds and CO2 allowance prices

Hammoudeh et al., 2020.

RESEARCH HYPOTHESIS DESIGN

According to the literature review and considering the research aims, the following hypotheses are formulated:

- ***H_1.*** In the regime of low volatility/expansion, the Dow Jones Commodity Energy Index presents positive and significant effects on the performance of the European Union Allowances (EUA) market.
- ***H_2.*** In the regime of high volatility/recession, the Dow Jones Commodity Energy Index presents negative and significant effects on the performance of the EUA market.
- ***H_3.*** In regimes of high volatility/recession and low volatility/expansion, green bonds produce negative and significant effects on the performance of the EUA market.
- ***H_4.*** In regimes of high volatility/recession and low volatility/expansion, conventional bonds produce positive and significant effects on the performance of the EUA market.

EMPIRICAL EXERCISE

This analysis uses a Markov-switching (MS) model, which was stimulated by the work of Hamilton (1989) and emerges as an extension of the work by Goldfeld and Quandt (1973).

The applicability of the model allows determining the expected durability of a state or regime (Kim & Nelson, 1999), as well as capturing between the states or processes changes in the average and in the variance (Maitland-Smith & Brooks, 1999), which are associated with transition probabilities.

Therefore, the model is defined as follows:

$$y_t = \beta_{0,S_t} + \beta_{it,S_t} X_{it,S_t} + \sigma_{S_t} \varepsilon_t$$

VARIABLES AND DATA SOURCES

Variable	Unit	Description	Source
CO_2 Fut	Euro	European Union Allowances Futures with first near contract expiration.	Quandl (www.quandl.com)
S&P Green	USD Dollar	The S&P Green Bond Index is a multi-currency benchmark that shows the performance of the green bonds market. The green bonds included present no minimum amount outstanding and the time to maturity must be at least one year. Nevertheless, the Index excludes the following categories of bonds: Bills, Inflation-linked and STRIPS bonds. The bonds are specified as 'labelled green' by Climate Bonds Initiative.	S&P Dow Jones Indices (www.us.spindices.com)
Sol Green	USD Dollar	The Solactive Green Bond Index is a market value weighted index that shows the green bond market. The index comprises bonds with maximum weight capped at 5% per bond and an amount outstanding of at least 100 million USD with time to maturity of at least 6 months Nevertheless, the Index excludes the following categories of bonds: Bills, Inflation-linked and STRIPS bonds. The bonds are specified as 'labelled green' by Climate Bonds Initiative.	Solactive (www.solactive.com)
S&P Agg	USD Dollar	The S&P Global Developed Aggregate Bond Index shows the aggregate performance of investment-grade debt issuance such as sovereign bonds, quasi-government bonds, and corporate bonds, excluding collateralized/securitized ones. The maturity must be at least one year.	S&P Dow Jones Indices (www.us.spindices.com)
DJCI En.	USD Dollar	The Dow Jones Commodity Index Energy shows the performance of energy sector futures contracts. The Index comprises oil market, gasoline and gasoil markets, heating oil market and natural gas market.	S&P Dow Jones Indices (www.us.spindices.com)

MODELS DENOMINATION

Designation	Specification	Time period (t)	Sample (S_t={1,2})
Model 1 (M1)	$CO2\ Fut_{i,t} = \beta_{0,S_t} + \beta_{1,S_t} CO2\ Fut_{t-1} + \beta_{2,S_t} S\&P\ Green_{t-1} + \beta_{3,S_t} S\&P\ Agg_{t-1} + \beta_{4,S_t} DJCI\ En_{t-1} + \sigma_{S_t} \varepsilon_{t-1}$	t ∈ {03/11/2014, …,09/30/2019}	Sample 1
Model 2 (M2)		t ∈ {07/30/2014, …,09/30/2019}	Sample 2
Model 3 (M3)	$CO2\ Fut_{i,t} = \beta_{0,S_t} + \beta_{1,S_t} CO2\ Fut_{t-1} + \beta_{2,S_t} Sol\ Green_{t-1} + \beta_{3,S_t} S\&P\ Agg_{t-1} + \beta_{4,S_t} DJCI\ En_{t-1} + \sigma_{S_t} \varepsilon_{t-1}$	t ∈ {03/11/2014, …,09/30/2019}	Sample 1
Model 4 (M4)		t ∈ {07/30/2014, …,09/30/2019}	Sample 2

TWO-REGIME MARKOV SWITCHING MODELS

Dependent Variable CO2 Fut.										
Models	Regimes	Co2 Fut (-1)	S&P Green (-1)	Sol Green (-1)	S&P Agg (-1)	DJCI En (-1)	Constant	log(σ)	LL	SBC
	R1	-0.0180	**1.2909****	-	-0.5951	-0.0220	0.1410**	**0.7309*****		
M1		[0.5109]	[2.2677]	-	[1.0542]	[-0.5596]	[2.0435]	[23.7253]	-3347.615	4.8582
	R2	-0.0347	3.4561	-	-2.9475	**-0.5155*****	-0.0524	**1.5312*****		
		[0.5871]	[1.5207]	-	[1.4936]	[3.5047]	[-0.1931]	[26.5438]		
	R1	-0.0460	2.6660	-	-2.1573	**-0.4722*****	0.0458	**1.4899*****		
M2		[-0.7561]	[1.18915]	-	[1.1178]	[-3.3690]	[0.1709]	[24.0625]	-3089.737	4.8307
	R2	-0.0165	**1.2568****	-	-0.5111	-0.0185	0.1235*	**0.7264*****		
		[-0.4485]	[2.1560]	**-**	[-0.8857]	[-0.4594]	[1.7369]	[23.3097]		
	R1	-0.0330	-	**4.0039****	**-3.6240****	**-0.5518*****	-0.0390	**1.5230*****		
M3		[-0.5704]	-	[2.3434]	[-2.1822]	[-3.7578]	[-0.1454]	[26.2796]	-3342.366	4.8507
	R2	-0.0186	-	**1.3662*****	**-0.7676***	-0.0247	0.1409**	**0.7251*****		
		[-0.5381]	-	[3.4344]	[-1.6896]	[-0.6270]	[2.0491]	[23.6138]		
	S1	-0.0510	-	**4.1030****	**-3.5894****	**-0.5136*****	0.0660	**1.4730*****		
M4		[-0.8692]	-	[2.4870]	[-2.2344]	[-3.7251]	[0.2538]	[24.4828]	-3083.871	4.8216
	R2	-0.0172	-	**1.3165*****	-0.6725	-0.0192	0.1232*	**0.7191*****		
		[-0.4769]		[3.2575]	[-1.4545]	[-0.47962]	[1.7374]	[23.1509]		

Notes: Z-statistics are shown in square brackets. LL denotes the maximized log-likelihood value.
SBC refers to Schwarz Bayesian Criteria information. ***, **, * indicate significance at 1%, 5% and 10%, respectively.

QUANTILE REGRESSION MODELS

Dependent Variable CO2 Fut.						
Models	Quantiles	CO2 Fut. (-1)	Sol Green (-1)	S&P Agg (-1)	DJCI En (-1)	Constant
M3	10th	-0.0050	**2.5725*** **	**-1.8238** **	**-0.2622*** **	-3.1350***
		[-0.0801]	[3.3126]	[-2.3075]	[-3.6470]	[-22.6283]
	25th	-0.02270	**1.7685*** **	**-1.2956*** **	-0.0937	-1.4831***
		[-0.6534]	[3.8213]	[-2.7867]	[-1.6298]	[-16.7194]
	Median	**-0.1063*** **	**1.4138** **	-0.8437	**-0.0791** **	0.1146*
		[-2.9092]	[3.3203]	[-1.6201]	[-2.3427]	[1.7755]
	75th	-0.0679	**2.3343** **	**-1.6573*** **	-0.0798	1.6241***
		[-1.6374]	[4.3522]	[-2.6493]	[-1.6007]	[17.6239]
	90th	-0.0402	**3.4394*** **	**-2.7671*** **	-0.0897	3.4697***
		[-0.7700]	[4.3209]	[-3.3540]	[-1.1241]	[22.3974]
M4	10th	-0.0216	**2.7182*** **	**-1.7378** **	**-0.2490*** **	-3.1137***
		[-0.3641]	[3.4073]	[-2.0930]	[-3.5166]	[-23.1634]
	25th	-0.0197	**1.9355*** **	**-1.3025*** **	-0.0898	-1.4900***
		[-0.5737]	[4.1966]	[-2.8356]	[-1.5213]	[-17.1328]
	Median	**-0.0917** **	**1.3492*** **	-0.6851	**-0.0838** **	0.0904
		[-2.2529]	[3.0888]	[-1.3136]	[-2.4846]	[1.3175]
	75th	-0.0528	**2.2086*** **	**-1.5294** **	-0.0697	1.6179***
		[-1.2548]	[4.1526]	[-2.4548]	[-1.3633]	[17.2162]
	90th	-0.0328	**3.3849*** **	**-2.7417*** **	-0.1032	3.4573***
		[-0.6187]	[4.1878]	[-3.2949]	[-1.3185]	[21.7763]

*Notes: A resampling method called Markov Chain Marginal Bootstrap A-transformation (MCMB-A) is applied, which is robust against heteroskedasticity. For more details, see Kocherginsky, He and Mu (2005) and Kocherginsky and He (2007). t-statistics are shown in square brackets. ***, **, * indicate significance at 1%, 5% and 10%, respectively.*

PREVIOUS STUDIES *vs.* FINDINGS

Previous studies	Previous evidence	Research hypotheses	Results obtained
Alberola et al. (2008) … Chevallier et al. (2019)	In expansion phases, there is a positive relationship between the leading energy index and the reference market's performance.	H_1. In the regime of low volatility/expansion, the Dow Jones Commodity Energy Index presents positive and significant effects on the performance of the EUA market.	The empirical evidence indicates **rejection of H_1**.
Chevallier (2011) … Zhu et al. (2019)	In recession phases, there is a negative relationship between the leading energy index and the reference market's performance.	H_2. In the regime of high volatility/recession, the Dow Jones Commodity Energy Index presents negative and significant effects on the performance of the EUA market.	The empirical evidence indicates **non-rejection of H_2**.
Flaherty et al. (2017) … Kanamura (2020)	Both in expansion and recession phases, there is a negative relationship between the emission of green bonds and the reference market's performance.	H_3. In regimes of high volatility/recession and low volatility/expansion, green bonds produce negative and significant effects on the performance of the EUA market.	The results obtained lead to **rejection of H_3**.
Chevallier (2009) Tan & Wang (2017)	Both in expansion and recession phases, there is a positive relationship between the emission of conventional bonds and the reference market's performance.	H_4. In regimes of high volatility/recession and low volatility/expansion, conventional bonds produce positive and significant effects on the performance of the EUA market.	The results signal **rejection of H_4**.

INVESTMENT & POLICY IMPLICATIONS

What is observed?

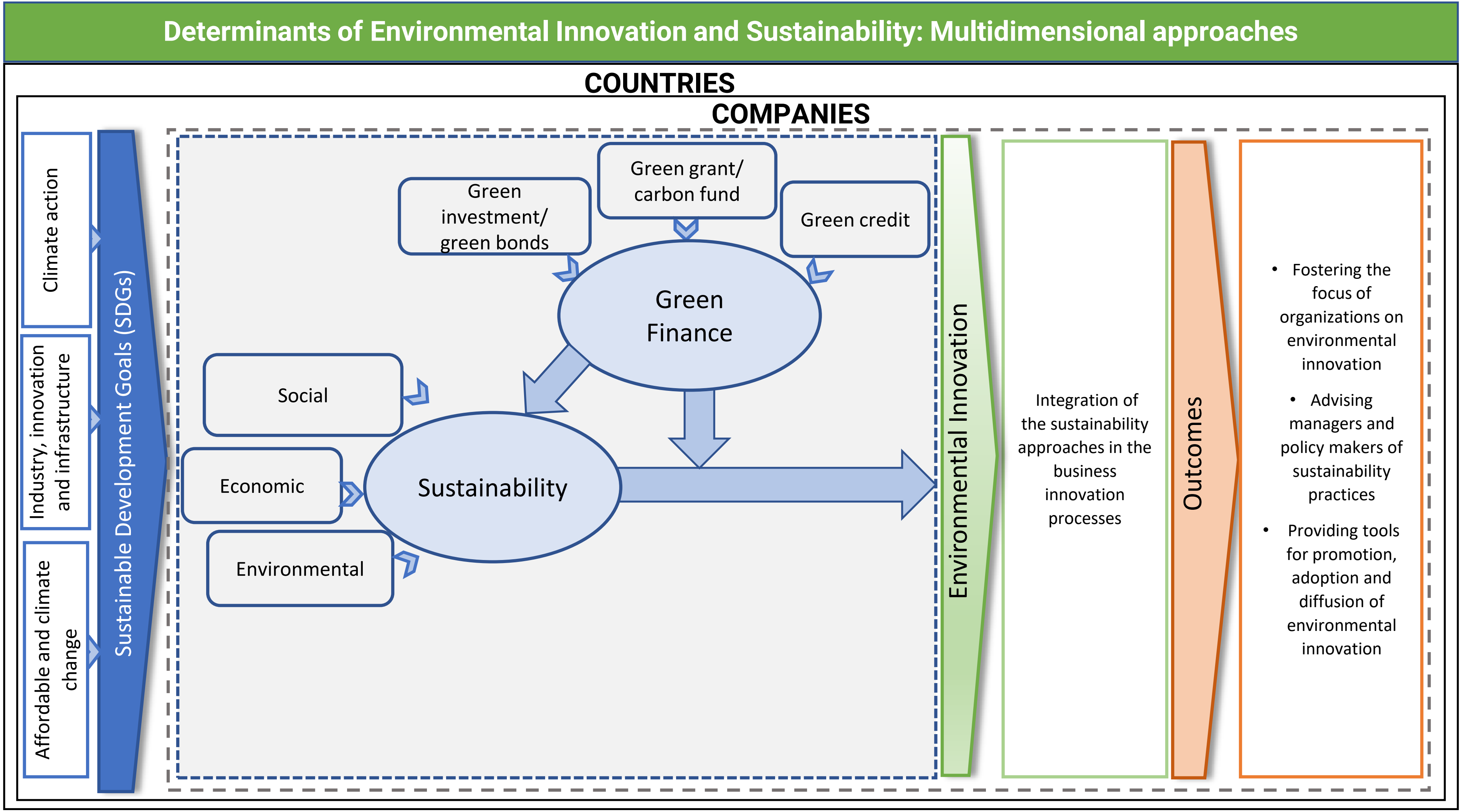
- There is a greater demand for green assets by investors, in that these assets show greater transparency and less volatility in the economic context.
- It is also observed a tendency of diminished demand for energy commodities given the restrictions on demand for EU-ETS from policies restricting energy production. However, non-linearities are found between carbon prices and the respective bond and futures markets of energy commodities.

What are the implications?

- These results are important both for investors and fund managers, since they allow distinct strategies considering volatility or economic activity, through a diversified portfolio structure and green/climate structure, by including fixed-income and futures instruments.
- The results obtained here are also relevant for policy-makers engaged in sustainable environmental policy, in that they provide a set of information necessary to develop assertive public policies for ensuring an effective transition to a green economy.

Future Research Agenda

This is a tentative roadmap for jointly exploring new research opportunities


Determinants of Environmental Innovation and Sustainability: Multidimensional approaches
COUNTRIES
COMPANIES
Climate action
Industry, innovation and infrastructure
Affordable and climate change
Sustainable Development Goals (SDGs)
Green investment/ green bonds
Green grant/ carbon fund
Green credit
Green Finance
Social
Economic
Environmental
Sustainability
Environmental Innovation
Integration of the sustainability approaches in the business innovation processes
Outcomes
• Fostering the focus of organizations on environmental innovation
• Advising managers and policy makers of sustainability practices
• Providing tools for promotion, adoption and diffusion of environmental innovation

Thanks!

Any questions?

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