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Making a Difference: Accounting for the Impact of Management Decisions in Environmental Management

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Abstract

Management decisions are typically meant to be making a lasting impact, or at least bringing us one step closer to a long-term goal. Yet there are situations where it is hard to link decisions made and results achieved. The problem gets more complex when comparing different backgrounds, as management quality is often assessed either in specific organizational context (Ghoshal and Bartlett, 1994; Coggburn and Schneider, 2003) or in a finite number of case-studies. These methods have been successfully used for a long time in corporate environment (Gong *et al.*, 2018) and for public sector decisions (Eller *et al.*, 2018), but their application is not as easy when facing problems that are affected by multiple economy-wide factors, and/or by variables that are not directly observable. We study the long term impact on management decisions in environmental management by using market information on different instruments used to manage and control environmental pollution and risk. The core reason for choosing this approach is that market data is able to account for economic reasons and capture changes that go beyond the scope of an individual corporation or a public agency.

Keywords: environmental management; policy assessment; climate bonds; Hurst exponent; market memory.

JEL classification: G13; G17; G18.

1. INTRODUCTION

Recent estimates have put funds required to mitigate climate changes well over two hundred billion USD per year (Reichelt, 2010) which indicates that innovative means to involve private capitals are both necessary and desired in order to provide enough funding. Climate bonds, also referred to as green bonds have already made their way as one of the possible funding sources for central governments and municipalities thus getting more recognition in the corporate world (Flammer, 2018). Investment vehicles with funds dedicated to green project have been analyzed in several papers including (Pham, 2016) and (Sabbaghi,

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2011), yet these studies are focusing on financial performance and volatility analysis, rather than on the relation between these instruments and environment management decisions. In Morel (2012) and Galaz *et al.* (2015) emphasis is put on development of these instruments and their links to commodity markets. Banking institutions also involve themselves in various green projects. Hence, the term ‘green banking’ becomes a central focus point for many researchers and practitioners (for an extensive discussion on the topic, see Apostoaie, 2018). While it is important to track and facilitate the growth of dedicated funding for green projects, it is also of great significance to be able to estimate the impact of different policies and decisions on their development. Before being able to assess the effectiveness of policy making it is necessary to properly define what a good decision is. A number of papers (Vlek *et al.*, 1984, Kreps, 2018 and Dietz, 2010) have focused on this question, yet we will define a simple criterion that could be applied for decisions that are expected to have a sound financial impact. We shall consider a “good decision” one that has the following characteristics:

- It matters – causing a significant and lasting impact.
- It moves – getting us one step closer to our goal.
- It merges – our understanding and our knowledge.

Although the definition may seem quite broad at first glance, it can be used in different contexts and can also help assess decisions that have impact in multiple areas of economic activity – resp. that affect different financial market segments. Significant and lasting impact on the other hand is particularly important when analysing policy making and importance of environment management decisions in long term. Moving us closer to the specified goal (or goals) and merging existing knowledge and understanding indicate that decision has been made in line with the defined goals and is justified one, rather than a random choice. Taken together these three characteristics can be used to separate decisions that were both “on target and on purpose” from those that had no real impact or whose success/failure was brought by chance. They are also in line with concepts treating decisions as exercise of options (Kabaivanov *et al.*, 2013) and can therefore better account for flexibility embedded in every decision made.

When applied to environment management, these characteristics boil down to a common rule that important decisions are those that result in significant changes in the way markets move and in the way individual economic agents adjust their behaviour. The combination of these characteristics allows to get an assessment of decisions taken under distorted and incomplete information, having variables that are not directly observable and/or being influenced by a number of economy-wide factors.

2. ENVIRONMENTAL CHANGES AND FINANCIAL MARKETS

Coupling of economic growth and emissions have been analyzed in a number of papers, both on a global (York and McGee, 2017; Wu *et al.*, 2018) and national scale (Yadong *et al.*, 2013) and despite that recent UN reports (UN - Economic Analysis & Policy Division, 2018) indicate this dependency weakens, improvements are far from sufficient and far from reaching goals defined in Paris agreement of 2015. With global growth estimates for 2018 and 2019 set at about 3.2% investments in renewable energy sources (estimate provided by the The World Bank, 2019), reforming use of fossil fuel and keeping man-made greenhouse emissions in check require additional spending and incentives for companies and individuals alike. Application of appropriate measures requires spending of large amount of money, that are not always available for corporations and government agencies. Therefore, issues of green bonds offer a valuable source of funding for projects with climate benefits. With estimated new issues of 25.8bn USD in 2018Q1 (Climate Bonds Initiative, 2018) (which would continue to support rapid expansion from the last years) this market segment is growing rapidly but is still dependent on establishing regulations that would allow to broaden its scope and allow for participation of more companies and institutions. Markets are further influenced by decisions that affect their ability to prove there is additional added value, rather than just information gains (since proceeds are used in a dedicated area or invested in specific assets). Green bonds are also facing challenges like necessity to increase transparency (in order to prevent greenwashing) and need to prove they are not just a way to repackage existing debt which further highlights market dependence on regulations and expansion-supporting decisions.

After almost a decade after the first issuance of a green bond, the geographic patterns of issuance are still significant with US, China and EU accounting for most of the issues in 2017 (Climate Bonds Initiative, 2018; UniCredit, 2018). With regard to our goal this provides an opportunity to pinpoint few regions which are important for the issuance, thus limiting the number of factors and regulatory decisions that may influence market development. Another distinctive feature of the climate bond issues is that sovereign issuance accounts for large part of the total amounts (approximately one third as in (Climate Bonds Initiative, 2018). That allows to use the market movement as a proxy for assessment of government policy for environment protection.

3. METHODOLOGY

In this paper we build on two approaches to search for decisions that influence in a significant way green bond markets – checking for time series anomalies and testing for long-term memory patterns. Anomalies detection comes down to discovering outliers relative to a predefined model or unusual changes in the market development that can be attributed to specific decisions. The typical implementation includes either classification algorithms (in which case one has to classify a change as “special/unusual” or one that is in line with the predefined assumptions/model) or forecasting of the time series and later on analysing the differences between observed and predicted values. Both implementation methods have their advantages and drawbacks. The anomalies detection approach is not perfectly suited for the purpose of this paper as it can identify the outliers but cannot provide information on their relative importance, nor can it assess how long the effects that caused them have been driving market changes. For this reason we have decided to test market data for long-term memory patterns, as it would allow to include different investment horizons in the analysis (thus taking under consideration preferences of market participants) and at the same time account for the long-term effects of important regulations and environment management decisions.

We use Hurst exponent (Hurst, 1951) to analyse for long-term memory and lasting effects on the climate bond markets. The long-term memory effects in a time series X_t (1) are estimated in accordance with equations (2) - (6), provided that a “memory window” (e.g. a period of given number of observations – *n*) is defined. Equation (5) is the standard deviation of the values within the specified timespan and H_q is the exponent.

$$X = (X_1, X_2, \dots, X_n) \quad (1)$$

$$Y = (X_1 - \bar{X}, X_2 - \bar{X}, \dots, X_n - \bar{X}) \quad (2)$$

$$Z_i = \sum_{k=1}^{i} Y_k \text{, за } i = 1,2,\dots,n \quad (3)$$

$$R(n) = max(Z_1, Z_2, \dots, Z_n) - min(Z_1, Z_2, \dots, Z_n) \quad (4)$$

$$S(n) = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(X_i - \bar{X})^2} \quad (5)$$

$$\mathrm{E}\left(\frac{R(n)}{S(n)}\right) \infty\ const. n^{Hq} \quad (6)$$

Hurst exponent values can be used to indicate a change in the trend (provided that H_q is larger than 0 but less than 0.5), a presence of serial autocorrelation in the time series (in case H_q is higher than 0.5) or random behaviour (if we have exponent values that are close to 0.5). Testing for long-term memory on financial markets has been done in the context of market and information efficiency in Martinez *et al.* (2016) and Bariviera *et al.* (2012), while in Domino (2011), it is employed as a way to detect market trend changes. Our goal is slightly different as we aim at using the Hurst exponent in terms of analysing the impact of management decisions, thus we focus on persistence and anti-persistence periods, regardless of the market direction or the exact degree of the change. The start of a persistence period would be eligible then for further investigation if a decision has given a new general direction. On the other hand, periods of time dominated by return-to-mean behaviour (Kabaivanov and Markovska, 2017) are less likely to be influenced by specific regulations or common decisions.

4. GREEN BOND MARKET DATA

In this paper we use green bond index time series in order to represent the market development of climate bonds over the last ten years. Due to the fact that these financial instruments share a lot of common characteristics with other bonds, we can benefit from all the existing valuation and credit rating assessment methods. At the same time, due to the fact that proceeds of these securities are earmarked on green projects (for example the investments are dedicated to reducing the impact of GHG) we can use the available market data to assess the impact of environmental management decisions on a larger scale. As a representative of green bond market, we have used the S&P Green Bond Index values over the last 10 years -covering a period of 2008-11-28 to 2018-04-13.

Figure no. 1 represents the values of the index, indicating the substantial growth in value and investor appetite for climate bonds. Table no. 1 contains information on the major characteristics of the index values, of which we should note the negative skewness (-1.08339) and low kurtosis (0.47522). A stationarity check shows an ADF test value of -

1.9483 (with lag 13 and p-value of 0.6002) that does not allow to reject the null hypothesis and the presence of unit root in examined time series.

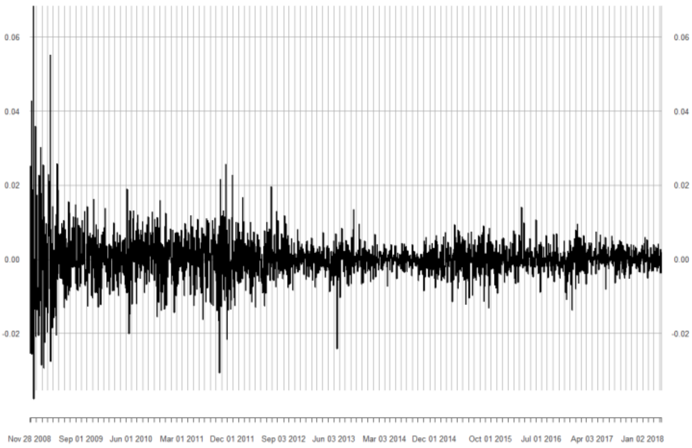
Source: "S&P Dow Jones Indices," 2019

Figure no. 1 – S&P Green Bond index values / Index values covering period 2008-11-28 to 2018-04-13

Table no. 1 – S&P Green Bond index characteristics

Parameter	Value
Number of values in the period [daily values]	2441
Mean index value	127.184
Median index value	129.59
Standard deviation	10.26013
Kurtosis	0.47522
Skewness	-1.08339

Source: Calculated from S&P Green Bond Index values



Source: Calculated daily changes of Green Bond Index values

Figure no. 2 – Daily changes of S&P Green Bond index values (period 2008-11-28 to 2018-04-13)

Figure no. 2 shows that except for the end of 2008 and 2011 there are no large periods of increased volatility. In fact the generally lower volatility of the green bonds can be attributed to the fact that holders are less willing to sell them quickly in case downturns (partly due to their expectations fuelled by recent market segment growth and also by the fact that most of these securities are issued by institutions with high credit rating). This combined with the low kurtosis indicates that there will be fewer extreme values, thus large changes will be easier to identify and compare with important decision dates.

In accordance with equation (1) we have selected two different periods of time to calculate Hurst exponent – 5 days and 22 days. Roughly that corresponds with an investment horizon of one week to one month. While it is possible to select different time spans, we believe that selected two are sufficient to demonstrate the use of Hurst exponent and they also are sufficient to 1) make sure market adapts to changes in very short term, and 2) fit within a framework of regular monthly reviews.

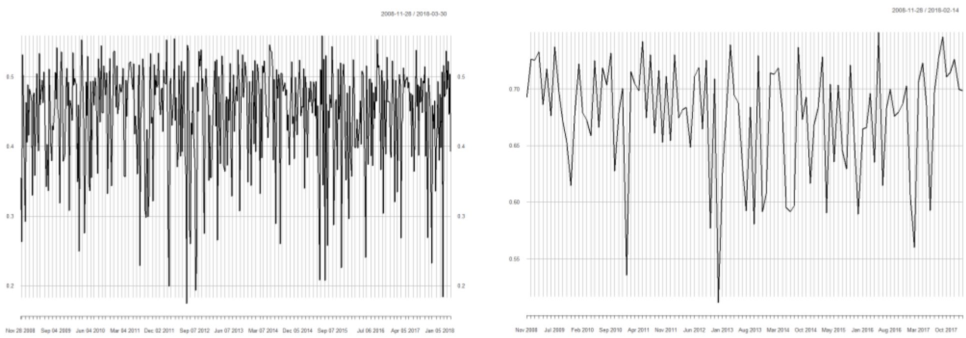
5. NUMERICAL RESULTS

Calculated values of Hurst exponent are designated in Figure no. 3, where short term values (over 5 day horizon) are on the left, while monthly horizon values are on the right. The mean value of the exponent in the longer period is considerably higher (0.6763), compared to the weekly horizon (0.4446). This is expected since over longer horizon the effect or daily random changes is less evident, but it also helps to confirm the fact that decisions aimed at supporting the climate bonds market have had a positive effect. The fact that 22 day average Hurst exponent is higher than 0.5 (indicating a trend), while 5 day values mean is lower than 0.4446 (thus indicating a mean-reverting behaviour) also emphasizes the fact that market has not experienced deep and lengthy crises in the examined period.

Table no. 2 – Summary of Hurst exponent calculations

Period/Hq	Min	1st Q	Median	Mean	3rd Q	Max
5 days	0.1744	0.4031	0.4656	0.4446	0.4954	0.5586
22 days	0.5112	0.6533	0.6849	0.6763	0.7145	0.7498

Source: Calculated from S&P Green Bond Index values



Source: Research results – calculations of Hurst exponent

Figure no. 3 – S&P Green Bond Hurst exponent values over short 5 day horizon (left) and longer 22 day horizon (right)

In addition to tracking down general market conditions, Hurst exponent analysis can also be used to consider the effects of individual important decisions – like for example launching of ICMA Green Bond Principles in April 2014 is followed by a period in which the exponent moves in a more narrow range, compared to the time before that. Taking into account that this range is well above 0.5, this provides further support for the benefits of the GBP establishment. In a similar way, changes in the Hurst exponent value can be used to track down positive effect of developments in regulations and political decision in 2016 – in particular the entering into force or Paris COP21 in November, which in fact turns the green bonds into a global asset class and expands the reach of the market segment.

To sum up, using Hurst exponent value we can assess the impact of individual decisions, as well as market efficiency and presence of trends. Considering that this is done with a specific time horizon, this allows to run the analysis over different time spans, serving different purposes:

- Long horizons would make it possible to assess the efficiency of decisions that affect all participants and/or market structure – like for example new regulations on what qualifies as a green bond. In the context of climate bonds, it is not yet possible to check very long periods of time, due to the fact that markets are relatively new instruments.
- Short horizons would make it possible to assess if there is a mean-reversion behaviour on the market or changes that are rather following a random walk.
- Intermediate horizon would make it possible to assess the speed of full acceptance of new rules and changes.

A combined use of different horizons would allow to get a better overview of market participants behaviour, which could in turn help take a better directed and better justified decisions. Therefore the use of exponent values is not only limited to retrospective analysis but could support planning as well.

6. CONCLUSIONS

Climate bonds are innovative financial instruments that allow to attract private funding to projects mitigating climate change and facilitating implementation of environmentally friendly programs. We have used S&P Green Bond data and calculated Hurst exponent over different investment horizons – a short 5 days (week long) horizon and a longer one of 22 days-(one month). Our results indicate that a long-term trend is present, which is in line with the observed growth of the green bonds market and its recognition as a global asset class. Short-term fluctuations on the other hand, exhibit a pattern of mean-reversion or are closer to a random walk at different points in time. When analysing the market movement with different time spans it is possible to enrich traditional approaches and obtain information on acceptance and effects of different regulations and political decisions. The approach applied in our research can be of use for institutional investors, government bodies or bond issues in order to better plan, execute and assess their investment and regulation decisions.

We also believe that Hurst exponent analysis can also be used in future when climate bond markets will have to face further expansion and providing more options for smaller investors to participate in.

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