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Analysis of low carbon indices' performance

Comparison with traditional indices

Author: Marlène Bouhon
Supervisor: Professor Leonardo Iania
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INTRODUCTION

Environmental concerns have been gaining attention during the last decades. The continuous and accelerating overuse and destruction of natural resources has grown more and more threatening to living beings and their environment (Fransson and Gärling, 1999). In this scope, environmental groups have made their goal of educating society on those issues as well as on the way they can all have an individual impact to solve them. Different solutions have, therefore, been put in place to tackle these problems.

The regulation of environmental behavior has increased all over the world and nations have gathered in the attempt to tackle the problem. According to Popescu (2014), the main obstacle is the cost of the transition from a high-carbon emission economy to a low carbon one. And while regulations provide tools such as carbon tax or trading, a lot remains to be done. The development of green investments both at corporate and institutional levels could, consequently, be the solution closing this gap. Nevertheless, investors seem to believe that a trade is to be made between the performance and the sustainable aspect of their investment.

Moreover, environmental concerns increasingly take part of a bigger picture that brings several aspects jointly: the ESG. This acronym stands for Environmental, Social and Governance. Those three pillars are more and more seen as linked in the construction of a more sustainable world. Hence, it is important to understand this particular context that characterizes the beginning of the second millenary.

In this scope, this master thesis will jointly give an overview of the literature on ESG concerns and more deeply on low carbon action. This will be done through a first insight into the current global situation. Then, the literature will be reviewed on the role of corporates in the achievement of this targeted more sustainable world. Finally, the theoretical part will focus on the institutional level and especially on indices.

The goal of this paper is to compare the performance of low carbon and traditional indices. It will, indeed, allow us to verify or invalidate the assumption made by investors on the necessity to give up on a part of their returns in order to have a positive impact. Our analysis will, therefore, be based on several tests and models exposed later on.

I. ISSUES AT STAKE

It seems important, before going deeper within this master thesis, to set the scene.

Today, more and more interests are pointing out the issues of our time, including among others, social and environmental concerns about global warming, inequality, poverty, etc. As a response, society gets involved every day to spread the word and increase awareness on these matters.

The arising issues are different in each region, but they require global action. Indeed, while some parts of the world suffer from climate changes – which the entire humankind is responsible for -, others are facing even more direct human impact such as mass migration or privacy and data security as shown in the figure below (MSCI, 2019):

Figure 1: Current issues by region[1]

Therefore, people and even more companies are nowadays increasingly expected to be responsible citizens, respecting environment and society on top of satisfying personal comfort and internal stakeholders.

[1] https://www.msci.com/esg-investing#what_is_ESG

In 2015, an important step forward was made at global level through the Sustainable Development Goals (SDGs). This agreement implemented by the United Nations was one of the consequences of this rising awareness. Countries and governments have started to act to protect our planet and its citizens. Their objective is described by the UN as to determine a common action plan to solve these great problems. The SDGs are seventeen global goals (see appendix 1) the world should achieve by 2030 aiming at making a better world on several matters and basically have a chance to solve the environmental issues. These seventeen goals are further divided in 169 objectives in order to achieve all aspects following specific targets (United Nations, 2015).

On this path, the Paris agreement is an arrangement between the member nations of the United Nations (UN) that was signed by 196 countries. It focuses on the environmental aspects of the SDGs. In the 30 first days of the agreement's existence, 55 parties had already ratified the agreement. Those were estimated to represent at least 55% of the total global greenhouse gas emissions. The global targets of the action plan are stated in the convention as (United Nations, 2019):

1) Holding the increase in the global average temperature below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;

2) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production;

3) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

The Paris agreement supports the achievement of the SDGs by tackling climate change which – according to the UN (2019) - represents the biggest threat to sustainable development. The consequences of climate change can be witnessed everywhere in the world, but it is hitting the most vulnerable populations first. Moreover, they impact both humankind and other species through: "*significant species extinction, extreme weather events, enormous risks to global and regional food security, consequential constraints on*

common human activities, and increased likelihood of triggering tipping points and limited potential for adaptation in some cases" (Zhang, 2009).

The fallouts have been noticed as far as 1950 and are exacerbating. According to the IPCC, the Intergovernmental Panel on Climate Change (2014), the main observations relate: "*a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in extreme high sea levels and an increase in the number of heavy precipitation events in a number of regions*".

Climate change is the result of the global warming of the atmosphere, itself caused by the greenhouse effect. The Green House Gases (GHG) inducing this effect are naturally present in the air but have severally increased due to human action such as fossil fuels burning, cutting down rainforests and farming livestock. CO_2 in particular, is responsible for 64% of the global warming caused by men (European Commission, 2019). In the last 800 000 years, carbon dioxide atmospheric concentrations have never been so high. This effect is furthermore driven by economic and demographic growth (IPCC, 2014).

It is important to note that the goals of both the SDGs and the Paris agreement are extremely challenging and according to Stewart (2015), three issues still could negatively affect their realization. The first one is the fact that the agreements are international. Countries will inevitably interpret the goals in different ways and will put different mechanisms in place to achieve them. Secondly, the agreements do not specify the underlying economic structures needed, which could be tricky particularly for SDGs such as reducing inequality. Finally, there is no real effective integration of the sustainability goals with the economic goals. In the case of economic growth for example, it would require that either economic growth is only promoted with the guarantee of sustainability, or that growth would be redefined as 'green growth' in order to be consistent.

The GSIA highlights in its report (2016) that some differences are already to be observed at regional level. On one hand, the European Union has the objective to reduce its greenhouse gas emissions by at least 40 percent before 2030. To achieve this target, an additional 177 billion per year will be necessary starting in 2021 which means that new funding methods will be required to find this amount. While the United States (which represent the world's second largest emitter of greenhouse gases), committed to a 26-

28% reduction of greenhouse gas emissions by 2025. If in the United-States, the Obama administration started to put in place several action plans, they have been endangered by both its successor's administration and pro-fossil fuel powers. Finally, the world's largest emitter of greenhouse gases, China has pledged to a 60-65% reduction of greenhouse gas emissions by 2030 compared to its level in 2005. On the financial side, it represents an annual investment up to $640 billion. At least 85% of this amount should come from the private sector. And while the target seems quite difficult to reach, the issues at stake are even more important in China as public health is threatened by the level of air pollution.

II. THEORETICAL CONTENT

In this chapter we provide the necessary tools to understand the analysis conducted in this master thesis. We will start by giving an overview of sustainable challenges at corporate level before focusing on institutional investments. Several key theoretical concepts will be exposed and a deeper explanation of socially responsible investments (SRI) will be given. Finally, we will focus on financial indices.

1. *CORPORATE INVESTMENT IN SUSTAINABILITY*

As stated earlier, companies are more and more seen as a drivers of sustainable practices. As the world is evolving, so is business and the role that companies are expected to take will be reviewed in this section.

In order to get an idea on what has already been researched concerning sustainable investments in companies, the literature will now be thoroughly reviewed. First, a distinction can be made between major global companies and smaller, more local companies. Second, the extent to which companies report about their sustainable investments is also considered a good indicator of corporate social responsibility.

Already in 2000, Rondinelli and Berry stated that "*Proactive environmental management practices have become an integral part of the business operations of most international corporations*.". They argue that corporate citizenship goes beyond being a philanthropic approach of donating money and merely promoting welfare and does not stop with just satisfying the external shareholders.

Accordingly, they defined five points of efforts related to internal management practices. First, the multinational companies can invest to outperform regulations, i.e. performing better than is required on all regulated aspects by creating ambitious health, safety and environmental standards. Second, pollution prevention and clean manufacturing practices in both internal as external supply chain players are key to improve internal management practices from an environmental point of view. Thirdly, investments can be made to redesign products as well as processes. Fourth, reducing the materials used and

recycle or reuse as much as possible will help solve both resource depletion and waste disposal problems. Lastly, resource conservation consisting of reducing the use of water and other natural resources as well as replacing energy sources such as coal, oil and gas by renewables makes up a significant part of sustainable investments in multinational companies.

We immediately recognize that all of these investment options can be overlapping. However, it is exactly these efforts and investments in internal management practices by the multinational companies that Rondinelli and Berry (2000) consider the most beneficial to the environment. Moreover, apart from the environmental benefits, the companies in their research, which are limited to European and US based companies, experienced favorable financial returns from these investments.

Another research that was conducted in the scope of multinational enterprises reviews the trend towards non-financial reporting, which started in the nineties and has progressed in the 21st century. For this purpose, Kolk (2003) compared data on the Fortune Global 250 in 1998 and 2001, showing a sustained and significant rise of sustainability reporting for about half of the multinationals included.

However, some sector variations could clearly be identified. Even though the Chemicals & Pharmaceuticals industry is the industry in which the percentage of companies that are reporting about sustainability is the highest, this percentage decreased from 1998 to 2001. Other sectors showing a similar decrease are the Oil & Gas industry and the Metals & Manufacturing industry. For all the other sectors, the percentage of companies with sustainability reporting increased, with the greatest rise in the Utilities industry.

If reporting is not the same across industries, neither are the levels of carbon emissions. The chart below highlights those differences:

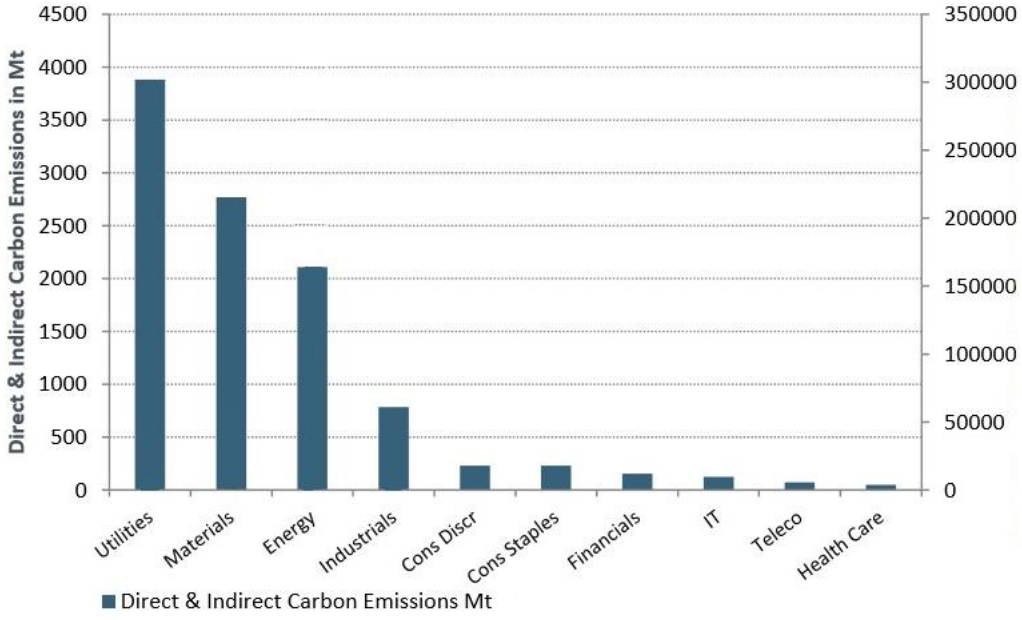


Figure 2: Current and future Carbon emissions by sector[2]

It is without any surprise that we find the Utilities sector as the largest carbon emitter, followed by Materials and Energy. It is interesting to notice that healthcare is the lowest emitter far behind those three. It makes sense that service-based sectors release less carbon than more industrial ones.

In addition of sector variations, country variations are also considered regarding reporting. Showing that among the largest economies, a slight reporting percentage decrease was found for the US whereas Japan, Germany, France and the UK based companies increased their sustainability reporting. However, an important remark here is that in Europe and Japan sustainability reporting was sometimes encouraged or even required by law (Kolk, 2003).

A final finding from this research concerns the different sustainable development goals and to what extent they are reported on. It was found that especially environment and ethical employment are tackled by the reporting mechanisms. The broader societal issues receive much less attention (Kolk, 2003).

In the same sense, Hayat and Orsagh (2015) state that environmental concerns such as climate change are an increasingly discussed matter at board meetings.

[2] https://www.msci.com/esg-investing#what_is_ESG

Unfortunately, the reporting on its own is not an absolute proof that companies are really engaged in sustainability. In particular, Hedberg and Von Malmborg (2003) argue that the reports are biased, as the companies will try to show the positive outcomes and leave out the less favorable results. Even worse than leaving out is the well-known phenomenon of greenwashing, which is described by Mitchell and Ramey (2011) as when companies "misrepresent themselves as engaging in earth-friendly behaviors."

We can add that in the last few years, we witnessed the rise of a new kind of partnership to actually reach those positive outcomes. Big corporates are more and more investing in clean startups that offer them the tools to become more sustainable. Indeed, while the research and development for cleantech can be very costly and time consuming, partnering with startups specialized in this field offers the opportunity to stay on top of technological and sustainable leadership (Bonzom and Nettessine, 2016).

Whereas the previous researches concerned big multinationals, other research conducted in this field consider small and medium sized enterprises (SME's). In particular, the paper by Moore & Manring from 2008 investigates the motivations for small and medium enterprises to invest in sustainability.

First, through investing in sustainability, the smaller companies can position themselves as valuable investments or even takeover targets for the bigger firms, as mentioned before. Second, they can create highly competitive networks of SME's in niche sectors, where the multinational companies are simply less successful. Finally, as was discussed by Rodinelli and Berry (2000) before, multinationals seek to have a sustainable supply chain, meaning that their suppliers and clients, which could be SME's, have to follow the same path.

The sustainability investments made by SMEs can thus help them create a competitive advantage and attract multinational clients or suppliers more easily. The research finally highlights that it is important not only to look at the big players and wait for them to make sustainable choices as the majority of enterprises are small and thus all together have a huge impact as well (Moore & Manring, 2008).

However, not only company managers should be interested in making sustainable choices. It is also a responsibility of the investors, the shareholders as well as debt-

holders of companies, that should make environment and society an essential aspect in deciding on where and in what to invest.

In the literature, many sources were found indicating that a required rate of return that is too high, might cause companies to take harmful investment decisions, as profits can be gained more easily. Richardson (2009), for example, argues that regulation must target the financial sector and that environmental standards should be put in place for financiers. Also, Al Gore, former VP of the US and David Blood, previous head of Goldman Sachs, said in an interview with the McKinsey Quarterly that sustainability investing is essential to create long-term shareholder value. They have even started their own business together, called Generation Investment Management. The aim of the company is to integrate sustainability in fundamental equity analysis (Mendonca & Oppenheim, 2007).

Corporate social responsibilities are hence more and more considered by enterprises because of regulations or through their own culture. Indeed, as stated by Adam (2013), leadership is truly important to bring a company to have a positive impact on the world. Three things are important to boost this positive impact. The first one is the strength of commitment and leadership qualities of the CEO. Secondly, the level of the Board's understanding of the relevance of sustainability to strategy and risk is key. The last essential element is a senior leader with the expertise, leadership skills and authority to make it happen and to successfully integrate sustainability into business practices.

In the table below, we summarize different incentives and obstacles encountered by companies while considering sustainability in their operations. In table 1, we distinguish internal and external incentives:

	Incentives	*Obstacles*
Internal	• Risk reduction both on operations (work accidents for example) and on reputation • Higher productivity • Cost reduction (more efficient use of resources) • Higher trust resulting in less control needed • Higher employee motivation and loyalty • Higher wages and social measures • More regulated governance	• Investment cost • Due diligence on the supply chain • Lack of management engagement • Employees' reluctance • Unawareness
External	• Technological leadership • Client loyalty • Premium image • Regulation (Avoidance of future taxes on environmental externalities) • Subsidies • Competition	• Belief of lower returns • Lack of reliable data • Clients' reluctance • Cost of transfer • Lack of standards • Fear of challenge

Table 1: Incentives and obstacles to sustainable investment at corporate level

2. AT INSTITUTIONAL LEVEL

While it is important to be aware of the current state of business practices by having a good understanding of the role of companies, this master thesis focuses on indices. It is consequently crucial to jump in on a more institutional investments area. Starting by reviewing financial theoretical content, we will go deeper on responsible investment practices before focusing on indices.

2.1. Financial theories

To understand the current state of those financial investments, it is important to review some theoretical content that forged the face of today's finance.

2.1.1. Efficient market hypothesis

The Efficient Market Hypothesis (EMH) was developed in the sixties by Eugene Fama. It states that prices already reflect all information that may have an impact on a stock. Which would mean that stocks are at all time traded at their fair value. It therefore holds that investors cannot find undervalued stocks or sell them above their prices. As a conclusion, it should be impossible to beat the market through selection and timing strategies. Higher returns are thus induced by higher risks only (Fama, 1965).

Following this approach, Jensen (1978) defined market efficiency by asserting that: *"A market is efficient with respect to information set Ω_t if it is impossible to make economic profits by trading on the basis of information set Ω_t."*

On his side, Roberts (1967) distinguished three levels of market efficiency by considering three different types of information sets as shown below:

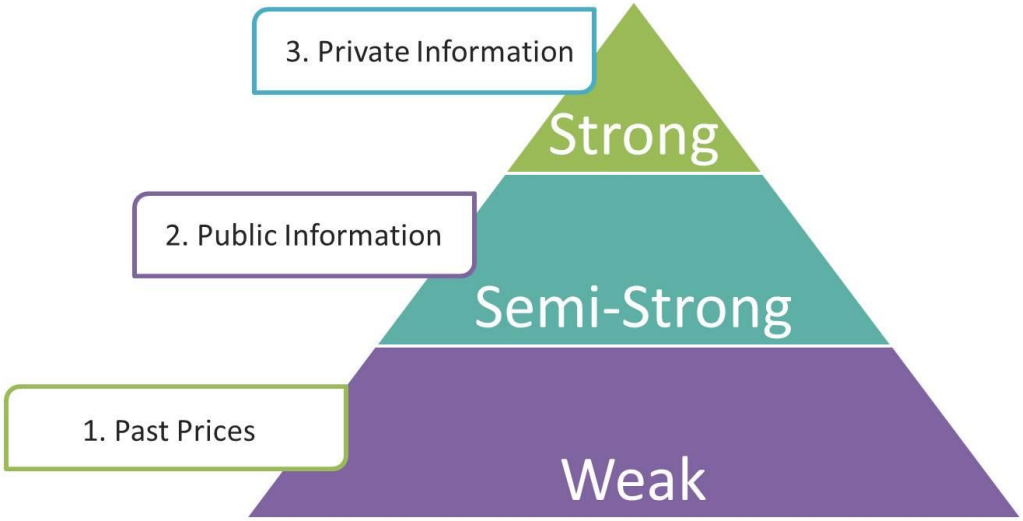


Figure 3 Market efficiency forms[3]

The weak form of the EMH is based on historical sequence of prices. It states that prices fully reflect the information contained in the past and that the future prices are not influenced by this past. Hence, investors cannot earn abnormal profits by using a strategy based on the analysis of past prices.

The semi-strong form of EMH adds a dimension to the weak form by saying that the current prices also reflect all publicly available information relevant to a company's securities in addition of historical data. As a conclusion, investors cannot earn abnormal profits by analyzing any of the public information of a company.

Finally, the strong form of EMH considers that all information regarding a company that is known to any market participant is entirely reflected in market prices whether this market is public or private (Malkiel, 1989).

We can conclude that information is a key component of any financial decision and that making fully informed decisions can be challenging in reality as markets are not always efficient.

[3] http://knowledgegrab.com/glossary/efficient-market-hypothesis-emh-8/

2.1.2. Modern portfolio theory

The Modern Portfolio Theory (MPT), is one of the most basic theories in finance. Indeed, it has set the foundations for portfolio creation and investment. The goal of this theory is to calculate the most efficient portfolio as the one that provides most return for the amount of risk that the investor is willing to take. It is based on the principle of diversification.

While investing, two types of risk can be identified. The systematic risk from the market fluctuation -which cannot be avoided- and the unsystematic risk which is specific to a firm in particular or a small group of companies. The diversification principle aims at reducing or eliminating the unsystematic risk. It states that if a portfolio is well-diversified, the investments with a strong performance compensate the negative results from poorly performing investments. Diversification can be applied at different levels (The Corporate Finance Institute, 2019):

Figure 4: Types of investment diversification[4]

- **The types of investments:** By including different types of asset classes such as cash, stocks, bonds, mutual funds, and more.

[4] https://corporatefinanceinstitute.com/resources/knowledge/strategy/diversification/

- **The risk levels:** The portfolio should consist of securities that have different level of risk. This will help to ensure that large losses are offset by gains in other areas.
- **The industries:** The stocks of companies operating in different industries tend to show a lower correlation with each other and investing in different industries will reduce the risk that is specific to each of them.
- **The foreign markets:** In order to avoid fluctuations in domestic markets, it is important to have a geographically diversified portfolio. Chances are that the correlation between assets traded in foreign and domestic markets would be low.

The MPT is based on the assumptions that markets are efficient, and that investors act rationally (which is not always the case in reality). It defines the risk as the standard deviation of return. The aim is to calculate a portfolio composition based on a weighted combination of assets so that the return of a portfolio is the weighted combination of the assets' returns. By doing so, the total variance of the portfolio return is accordingly lowered (Chen, 2019).

The natural conclusion to draw would be to say that considering ESG factors in the construction of a portfolio would reduce the universe of possible assets to consider and therefore would impact negatively the performance of such portfolio. While this argument must be considered, it is also becoming to be out of date. Indeed, the wider variety of approaches has increasingly improved the performances of those portfolios. As explained previously, several strategies are now used to avoid potentially adverse risk-return implications and portfolio biases resulting from systematic exclusions of whole industries (Candriam Academy, 2019).

2.1.3. Stakeholders theory

The stakeholders theory on the other hand, states that businesses should take into account all of their stakeholders and not only the owners of shares. A stakeholder is: "*any person or group that can affect or is affected by a business organization"* (Bhasin, 2019). It can include the media, the customers, the environment, the government, trade unions, and so on. As shown in figure 5 below:

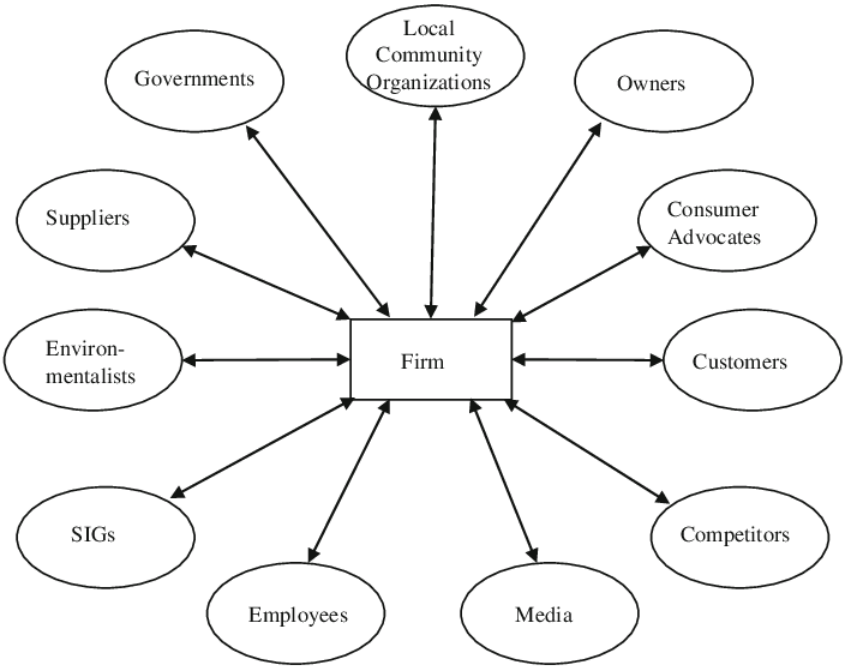


Figure 5: Stakeholders of a firm[5]

Indeed, all of these actors can be directly or indirectly impacted by the decisions of the firm. Thus, the managers should take into account their interests and create value for them and not only for the shareholders. This could in turn, help the organization to reach its fullest potential.

The stakeholder theory encourages to view the company with its global environment and with the impact it can have on it. Neglecting the interests of stakeholders could lead to unexpected results and in turn harm the company it-self. The firm is thus seen as part of a larger social body. This theory outlines six principles to determine the relationships that the firm should have with its stakeholders (Freeman, 1999).

[5] Freeman (2010)

First of all, clear rules must be determined regarding the interactions, definition of the relationship and transparency. The entry and exit points of the relationship must be defined.

Then, while the rules are defined, there must be a fair path to adjust them. Unanimous consent must be considered regarding the changes of rules governing the relationship.

Stakeholders should include not only the ones interacting with the company but also the ones who endure its externalities. Any group affected by the firm's operations must be considered.

Equality must also be looked at when it comes to contract costs. While it can be difficult if the cost is not quantifiable, it should always be equal among stakeholders or proportional to the benefits or harms induced by the relationship.

The agency principle asserts that the manager of the firm, as commending agent has a responsibility toward stakeholders, may them be shareholders or others.

Finally, the life period of the company must be considered. If we cannot say that a company can be everlasting, a sufficient longevity must be respected. Indeed, the fact that a firm would only exist for a limited amount of time would create opportunities for some of the stakeholders at the expense of others.

The stakeholders theory is a crucial principle to consider when it comes to SRI as the social impact is aimed for. To quote Freeman (2010): "*Saying that profits are the only important thing to a company is like saying, 'Red blood cells are life.' You need red blood cells to have life, but you need so much more.*"

2.2. Emergence of sustainable investment

As we can see from the literature, the definition of sustainable investments remains quite vague. On the other hand, David Pitt-Watson (2019), leading voice in the field of responsible investment, summons us to remember the very origin of investing, the purpose of finance, might it be ethical or not: It is first to safe-keeping assets, to provide an effective payment system, to allow the sharing of risk, and finally to match people who need money with people who have it.

And if it grew more complex with time, we know that the phenomenon of investing started about 5000 years ago in Mesopotamia. At that time, investing was a privilege kept for a very restricted amount of the population - the elite – and was mostly limited to estates and agricultural lands (Reamer and Downing, 2016).

Today, anyone with a minimum amount of money can invest. It means that the pool of investors has grown considerably, and with it, the diversification of the investment products. We, now, consider more and more ethical investments and sometimes forget that they have been around for quite a long time. If we go back to 5000 years ago Mesopotamian investments, we can find that social and environmental concerns already existed in the business area. For example, business commercial logging operations were already regulated and later a code was put in place to sentence to death people whose negligence "*caused the deaths of others, or major inconvenience to local citizens*" (Asongu, 2007).

According to Candriam Academy (2019), sustainable investing has increased during the last decades. The company assesses that this element is rooted in religious movements in Anglo-American countries during the 18th century but recognizes that the environmental concerns integration in investment as we see it today were mostly shaped in the early seventies. US SIF, the Forum for Sustainable and Responsible Investment, reported in 2016 that the number of funds incorporating ESG factors in 1995 was 55 (managing $12Billions in Total Net Assets) and raised continuously since then. In 2016, US SIF was counting 1002 funds active regarding ESG for a Total Net Asset amount of $2,597Billions.

On the other hand, Clark, Feiner and Viehs (2015) conducted a meta-study on the performances of sustainable investments. Their report highlights eight major key points:

1) *Sustainability is one of the most significant trends in financial markets for decades.*
2) *This report represents the most comprehensive knowledge base on sustainability to date. It is based on more than 200 academic studies, industry reports, newspaper articles, and books.*
3) *90% of the studies on the cost of capital show that sound sustainability standards lower the cost of capital of companies.*
4) *88% of the research shows that solid ESG practices result in better operational performance of firms.*

5) *80% of the studies show that stock price performance of companies is positively influenced by good sustainability practices.*
6) *Based on the economic impact, it is in the best interest of investors and corporate managers to incorporate sustainability considerations into their decision-making processes.*
7) *Active ownership allows investors to influence corporate behavior and benefit from improvements in sustainable business practices.*
8) *The future of sustainable investing is likely to be active ownership by multiple stakeholder groups including investors and consumers.*

And while this report shows that sustainable investing is growing, today there is no real homogeneity yet in the SRI terminology and the terms remain ambiguous. But as an example, Corporate Sustainable Responsibility (CSR) is defined by The Institute of Directors, a UK-based trade group, as (Lea, 2002):

> "*CSR is about businesses and other organizations going beyond the legal obligations to manage the impact they have on the environment and society. In particular, this could include how organizations interact with their employees, suppliers, customers and the communities in which they operate, as well as the extent they attempt to protect the environment*".

We probably still could find as many definitions of sustainable investment as we could count investors. And as mentioned in the previous section, the PRI[6] association states that the most concerning issue faced by investors today remains the climate change (UNPRI, 2019).

Additionally, the MSCI (2015) reported that: "*a growing number of large asset owners globally have announced that they plan to gear an increasing portion of their investments towards the "green" investments in general and towards low carbon solutions in particular. Some major asset owners believe that global warming may be a key risk factor in the long run that could affect their ability to meet future obligations. A growing number are integrating low carbon investments in their tactical or even strategic asset allocation*."

[6] Principle for Responsible Investment

In order to evaluate the risk exposure due to carbon emissions, investors must consider both the carbon footprint of their assets (through carbon footprinting) but also assess the risk of many carbon-intensive companies in their entire portfolio (Novethic, 2019).

Carbon footprinting is a technique that aims at calculating the portfolio's carbon footprint. It calculates the GHG emissions that can be associated to each underlying holding. Three types of emissions can be identified: Scope 1 emissions are directly produced by the firm's internal operations. Scope 2 considers the emissions produced indirectly through the energy that the company consumes. Finally, scope 3 accounts for the emissions generated in the entire value chain. But this method shows limitations. Indeed, we mentioned earlier that companies can be inaccurate when reporting on those matter (e.g. p.9). Additionally, this technique does not measure risk directly and does not consider the strategies put in place by the company to manage this risk. Instead, it provides a point of comparison to the standards and averages of a sector (MorningStar, 2018). To tackle that, a portfolio can then be decarbonized through divestment fossil fuel, green investments and low carbon index benchmarking for example (Novethic, 2019).

2.3. Strategies

In practice, it seems logical to establish abstract criteria which we could refer to in order to define what actions and practices are ethical (Candriam, 2019). Different strategies were therefore put in place in order to set the guidelines of responsible investment and clarify its dimensions. While these strategies can be applied on several ESG criteria at once, they can as well focus on carbon emissions only.

1) **Exclusion**

   The first one started in the religious sphere when the Methodist Church decided to place its money in stocks of companies that were seen as "appropriate" (Candriam, 2019). The concept of exclusion has the purpose of screening out industries and companies operating in such ways that they don't match the values of the investors. It can relate to human rights violations or simply disregarded industries such as alcohol, munitions, gambling and tobacco. While it has been declining due to its basic binary character, the exclusion strategy is the largest one

in terms of assets under management. As the decision of excluding certain types of industries is based on human values, the pool of investments considered can vary widely (Eccles, 2019).

2) **Engagement and voting**

Engagement activities and active ownership through voting of shares and engagement with companies on ESG matters is the next largest strategy, with a CAGR (compound annual growth rate) of 7%. The goal is not here to exclude companies but more to influence behaviours or increase disclosure on a long-term view. There is a real commitment of the investors seeking to engage with the company in order to make them improve on critical ESG issues. They also could be aiming at transforming their methods by changing their business model (Eccles, 2019).

3) **ESG integration**

The strategy that consists of integrating ESG in the investment decisions has recently grown at a very fast pace reaching 27% of CAGR. When using this strategy, ESG factors are taken into account in the fundamental financial analysis (Eccles, 2019). ESG investing focuses on three main areas (Candriam, 2019):

a) Environment: Which refers to the company's behavior regarding its energy consumption, its waste and pollution rejections but also on how it treats animals and natural resources. It also considers the risks related to the environment that may affect the company and how they are managed. It can go from compliance to the government's regulations to ownership of contaminated lands.

b) Social: Which refers to the company's business relationships. It must consider all the stakeholders related to the company. From the suppliers that intervene in its supply chain and their behavior, to its own employees and its impact on the community. The scope is as broad as shown previously in the stakeholders theory (e.g. pp. 16-17).

c) Governance: Which refers to the company ability of being transparent and dealing with voting rights. It also considers accounting methods, possible political relationships with members of the boards or conflict of interests.

Examples of the key issues targeted by each pillar are provided in the figure below based on MSCI ESG service (2019):

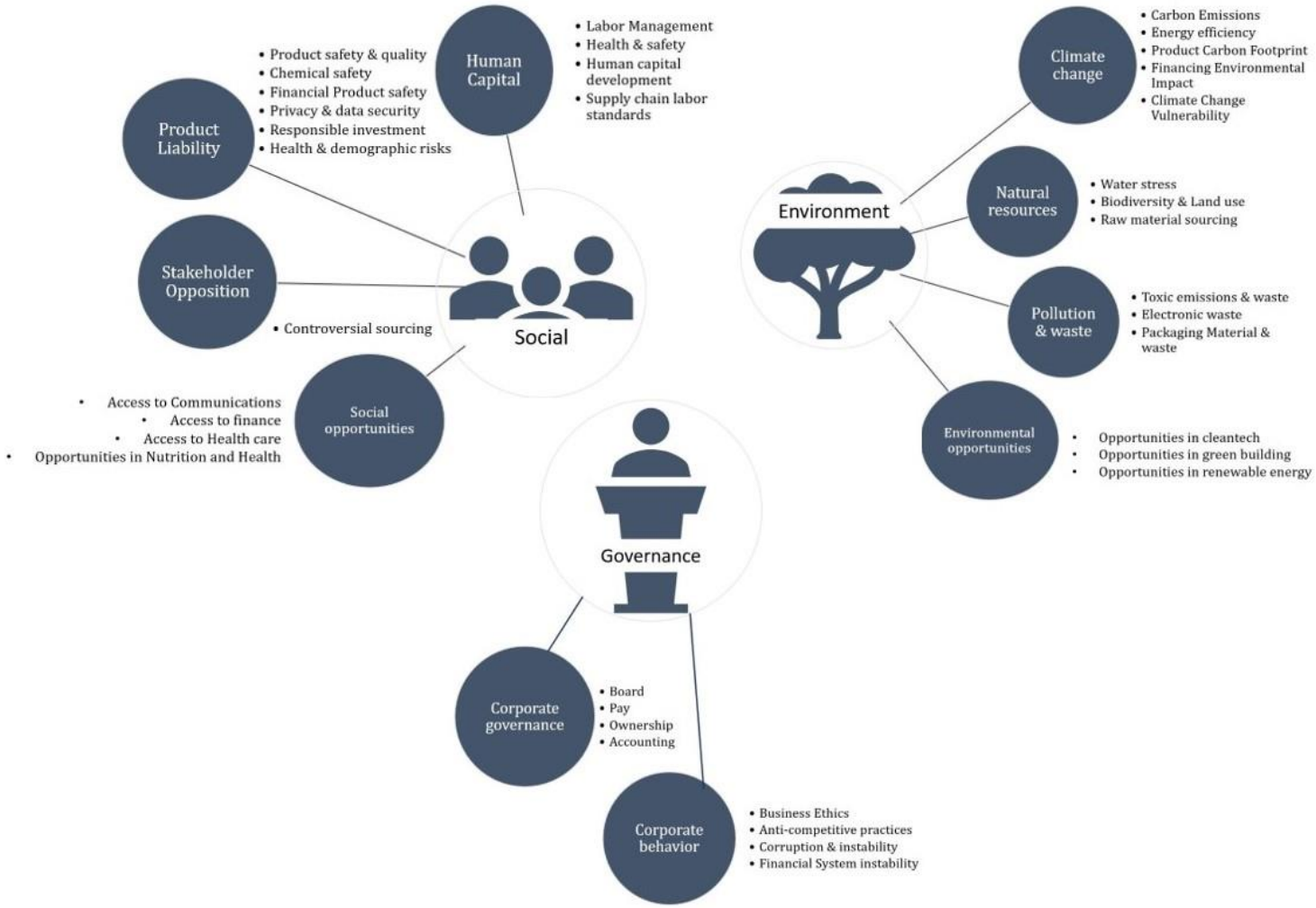


Figure 6: MSCI ESG example of investment impacts[7]

The integration process, hence, focuses on the potential risks and impact of ESG issues on a company's financials. This strategy considers ESG factors as equally important as more traditional ones like volatility, value, etc. But it sometimes remains difficult to find accurate ESG data (Eccles, 2019).

[7] Based on https://yoursri.com/media-new/download/jpm-esg-how-esg-can-enhance-your-portfolio.pdf

4) **Norm-based screening**

Like exclusions, norm-based screening screens out companies. The difference here is that the choice is not based on the investors' values but on globally established norms such as the U.N. Global Compact's principles regarding the environment, labor, human rights, and anticorruption (Eccles, 2019).

5) **Best-in-class**

Best-in-class strategies select companies leading or best-performing within a category, based on ESG criteria either in general or within an industry. Unlike ESG integration which focuses on a company's performance or industry-specific material issues, this strategy is based on overall sustainability rating of the company.

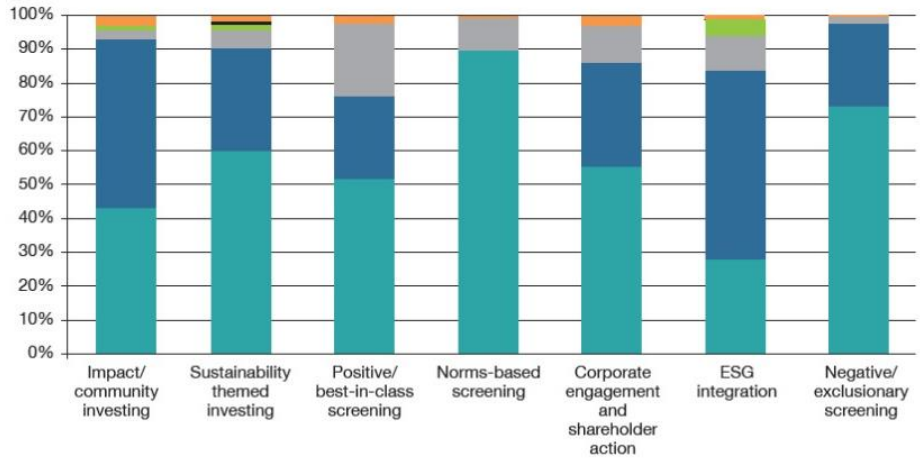
6) **Impact-investing**

As difficult as it is to truly define what "impact" can mean, this strategy focuses on the net positive contribution made by a company on society in general. It's based on the intention to have an impact on social and environmental matters – as considered in the Sustainable Development Goals (e.g. p.3) - while still generating financial returns. Even though Eccles (2019) sees this strategy as becoming dominant alongside with ESG integration and engagement, the data challenge is still very concerning at this time.

7) **Sustainability-themed**

Sustainability-themed strategies are focusing on companies developing solutions to societal challenges, such as renewable energy to combat climate change or financial services for poor communities. This strategy only represents 1% CAGR. Funds focusing on ESG particular issues address problems such health. To be considered as sustainability-themed they must conduct a thorough analysis of their investments (Eccles, 2019).

The table below relates the proportion in which each strategy is used in accordance with the region:



	Impact/ community investing	Sustainability themed investing	Positive/ best-in-class screening	Norms-based screening	Corporate engagement and shareholder action	ESG integration	Negative/ exclusionary screening
Japan	3.2%	2.6%	2.4%	0.9%	3.5%	1.2%	0.1%
Asia ex Japan	0.0%	1.9%	0.1%	0.0%	0.0%	0.2%	0.1%
Australia/NZ	1.1%	5.2%	0.0%	0.3%	0.0%	4.6%	0.0%
Canada	2.7%	20.3%	21.3%	9.5%	10.3%	10.1%	2.3%
United States	49.8%	22.2%	24.0%	0.0%	30.6%	56.0%	23.8%
Europe	43.2%	47.9%	52.2%	89.3%	55.6%	27.8%	73.6%

Figure 7: Regional Share, by asset weight, in global use of SRI strategies[8]

As we can see, Europe holds the largest part of assets managed through most of the SRI strategies. We can, as a result, conclude that this region has best integrated those strategies, especially in terms of a norms-based screening. Nevertheless, the United-States keep better scores on impact-investing and ESG integration methods.

Even though defining criteria to refer to in order to assess ethical investment seems quite easy to do, in practice the exercise gets tougher. Candriam (2019) reminds us that the chances are very low that an investment would be completely approved by all the stakeholders that it could involve. And while those strategies help us understand the way investments are made, they only capture a part of the decision.

While we see that Europe holds the largest part of assets managed through most of the SRI strategies, we can take a more global look at countries differences through the number of sustainable companies they shelter. When looking more closely at countries differences, the top 100 sustainable companies of 2017, gives us a first idea on region

[8] www.gsi-alliance.org/wp-content/uploads/2017/03/GSIR_Review2016.F.pdf.

variations in sustainability investments. As the US is still the largest economy in this world, it is no surprise that a significant number of companies are US based, as is shown in figure 8:

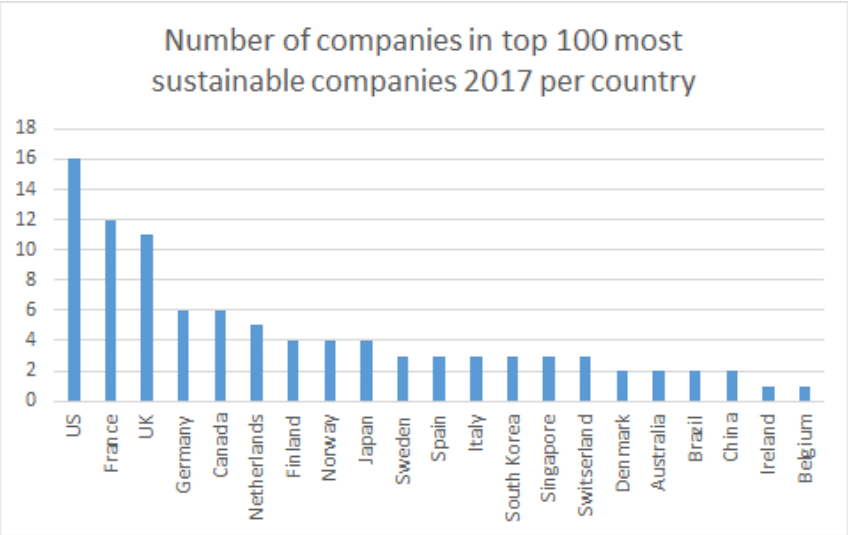
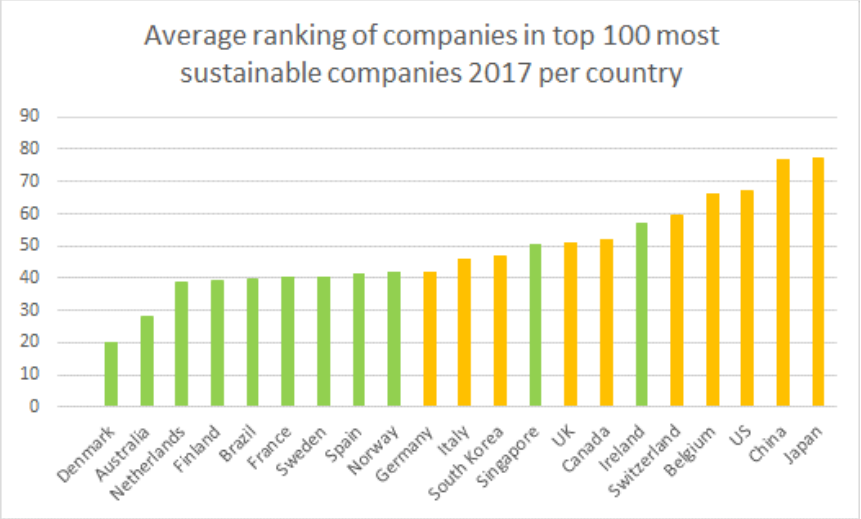


Figure 8:Number of companies in top 100 most sustainable companies 2017 per country[9]

However, when we look at figure 9 on the average rate for the countries where these companies are based, we see that the top 3 consists of Denmark, Australia and The Netherlands. On the contrary, the average ranking for the US is rather high, indicating that even though they have many players in the top 100, they are not the absolute top performers.

In fact, when we compare the global GDP's to this ranking, we can define three categories of countries. First, there are the countries that are in the top 20 of the largest economies according to GDP, but they have not a single company in the list. Accordingly, they do not appear in figure 9. These are India, Russia, Mexico, Indonesia, Turkey and Saudi Arabia. The second group are countries that do have one or more companies on the list, yet with their GDP, they could probably do more. These companies are highlighted in yellow in figure 9. The third group are countries in which the companies outperform others with respect to sustainability, highlighted in green in figure 9. The countries do not always have the highest GDPs, but they do put emphasis on sustainable management.

[9] https://countryeconomy.com/gdp



[10]

Figure 9: Average ranking of companies in top 100 sustainable companies 2017 per country

These results are mostly consistent with the ease of adopting the Paris agreements. For example, Turkey, who signed the agreements on 22 April 2016, yet has not ratified the agreements. The same applies for Russia. However, India, Saudi-Arabia, Mexico and Indonesia have signed and ratified the agreements in 2016. One can thus expect that these countries are sustainably ambitious and might have companies appearing in the top 100 list towards the future.

2.4. Incentives and obstacles to invest in sustainability

According to Nguyen (2018), many factors influence the rise of ESG concerns in investment strategies. The drivers can be divided into 3 main areas: the first one is the market demand. Indeed, some segments of the population (millennials, women, etc.) are more and more interested in the way their money is invested. The second one looks at regulation as many policies are currently under reform. Finally, the market factors to take into account are the risk mitigation, the ESG analytics and the performance.

As an individual takes the decision to invest, different factors are brought to attention. An investment decision is made with the purpose of earning some returns, financial considerations seek a higher return, a lower risk and a better risk/return ratio. But while

[10] https://countryeconomy.com/gdp

investing in ESG comes with the same concerns, extra financial considerations are also taken into account. According to MSCI (2019), an independent provider of research-driven insights and tools for institutional investors, those decisions are induced by three categories of beliefs:

1) The integration: It's characterized by the belief that integrating ESG will improve the portfolio's performances. It is based on the fact that they may help spot companies that could encounter difficulties when regulation or environmental concerns etc. will rise. This is seen by institutional investors as a way to manage risk as it allows them to filter the firms they choose to invest in. Indeed, it provides a filter for possible future scandals and fines. It is commonly followed by an exclusion strategy or a norm-based screening.

2) The personal values: In this case, investors try to align their investments with their values. While they are interested in reflecting their ethical, religious or political beliefs, they also want to make sure not to invest in activities that don't match those beliefs. Furthermore, US TRUST (2014) reported that this trend is growing as 67% of millennials believe that their investments should express their personal values while only 36% of Baby Boomers have the same vision. An ESG integration or a best in class approach are here more usual.

3) The positive impact: It is based on a desire for action and impact. The goal here is not only to make money but also to make a difference in the world. Those investors typically choose to invest in companies or frameworks (as highlighted before: SDGs for example) directed at external impact. While a combination of different strategies is the most likely, they particularly involve impact-investing as a driver.

Moreover, as the trend is growing, investors are able to find more valuable and accurate information about ESG matters and take more trustworthy decisions. In this increasingly increasingly connected world, they additionally feel more responsible for those decisions as each individual's prosperity is directly or indirectly linked to the well-being of the community. And while the demand is growing, so is the supply. A wide range of financial

products has been made available on the market to insure the fulfillment of this new appetite (J.P.Morgan, 2016).

While investing in ESG can be felt as the right thing to do, it is sometimes seen as a compromise on investments returns. Even though we notice that while most ESG institutional investors are convinced about the higher results and the lower volatility, they only invest a portion of their assets in SRI. Some of the reasons encountered are:

- The decision makers: The people who express their concerns toward ESG may not be the ones making the investments decisions.
- The human bias: There is a human bias that can intervene in the surveys. People often see ESG actions as the right thing to do and will be eager to say that they feel concerned about it, while they may not actually be acting on it.
- The Friedman approach: Friedman (2002) states that: "There is one and only one social responsibility of business – to use its resources and engage in activities designed to increase its profits so long as it stays within the rules of the game, which is to say, engages in open and free competition without deception or fraud."
- The reluctance of clients: it's not easy for an institutional investor to convince its clients to invest in ESG as they may simply not trust this approach.
- The fear of a loss of return.
- The transfer costs: there is a cost associated with the transfer of assets from regular investments to SRI.
- The fees: There is a higher cost associated with management fees in SRI.

Additionally, ESG are still seen as based on unreliable information because of their recent development, even though it has improved during the past decades. It is in fact very difficult to determine their monetary value and to integrate them in quantitative models. Furthermore, ESG-related disclosure hasn't yet been standardized and can sometimes be limited or even unverified (Hayat & Orsagh, 2015). Some people may also be convinced that this approach will not have enough impact and would rather take more radical action than investing in SRI.

On the other hand, asset managers can also show some reluctance to go for this approach. Indeed, the fact that SRI have less established benchmarks can make their task a lot more

difficult especially as ESG have no precise definitions and monitoring rules. This increased difficulty makes it more expensive and time consuming which in turn can be less profitable. Moreover, asset managers must keep a good relationship with their clients. Promoting a new approach may result in several negative outcomes such as: dissatisfaction of the client, raise of questions and challenges, loss of the client.

The more specific incentives inerrant to carbon emissions can be found in appendix 2 but are made of relatively the same issues. They are composed of 4 main aspects: Legislation, competition, reputation and willingness to tackle the consequences of climate change.

In table 2 are summarized the incentives and obstacles to invest in ESG:

	Incentives	*Obstacles*
Individuals	• Belief of higher returns • Personal Values • Desire of impact • Growing awareness • Growing amount of financial products	• Belief of lower returns • Lack of concern • Not being the decision maker • Cost of transfer • Higher fees • Desire for more impact
Asset Managers	• Belief of higher returns • Growing amount of available data • Growing demand	• Belief of lower returns • Lack of reliable data • Clients' reluctance • Cost of transfer • Lack of standards • Fear of challenge

Table 2: Incentives and obstacles to sustainable investment at institutional level

3. INDICES

Defining the scope of sustainable investments and reviewing the current state of those principles in the economy today as well as fundamental financial theories allowed us to have a clearer view of the current situation. If it sets the ground to have a global insight, it is yet not enough to answer the question posed by this thesis.

The goal here is to assess the performance of low carbon indices compared to regular ones. In order to do that, we must first define indices but also expose the sustainable aspect that we are trying to extract. By focusing on indices and not only on companies, we make sure to track a portion of the most popular investment tools. It also shows the advantage of having defined criteria to be able to make comparisons.

3.1. Theory on general indices

As defined by Chen (2019): "*An index is an indicator or measure of something, and in finance, it typically refers to a statistical measure of change in a securities market. In the case of financial markets, stock and bond market indices consist of a hypothetical portfolio of securities representing a particular market or a segment of it. (You cannot invest directly in an index.) The S&P 500 and the US Aggregate Bond Index are common benchmarks for the American stock and bond markets, respectively.*"

An index' value is a single number. Different methodologies can be used to determine this number. As an index can be used to represent different markets or sectors, they all have their own focus. In order to capture the trend of those markets or sectors, it is important to decide which companies are going to be represented by the index. This selection can be based on several shared characteristics (FTSE RUSSEL, 2019). An index can indeed gather the same type of securities from companies that have the same market capitalization size, the same sector of activity or that are active in the same region. Other financial components can also be taken into account such as: dividends, earnings per share, percentage of stock price, etc. Additionally, the different ESG investing strategies mentioned earlier can be applied at this stage.

Once the companies that will compose the index are chosen, a ponderation must be established. Indeed, each security will be represented accordingly to the methodology constituting the index. We identify three main approaches:

The first one is the unweighted index. This type of indices assembles securities by giving them the same weight. An identical amount is therefore invested in each security. This technique is increasingly being left out due to its very basic character. The second method is a price-based weighting. In this case each stock influences the index proportionally to its price per share. An average is then calculated to determine the index value. Finally, the last approach is to weight each index' components by their market capitalization. It has the advantage of including both the price of the security and the number of shares outstanding. Consequently, bigger companies represent a bigger portion of the index (Kenton, 2018). A derivative of this approach is the float-adjusted market capitalization selection. There, the market capitalization is calculated without taking into account all the shares but only truly tradable and investable shares.

As shown above, the methodology used to calculate the value is relatively different for each index, which means that we mostly refer to their fluctuation instead. Indeed, it is more important to have a view of the value changes encountered by the index to know how our particular portion of the market is doing compared to previous times (Jain, 2017).

Rauterberg and Versteint (2013) identified three main reasons why indices are a reference in the financial world. According to them, they are viewed as:

a) <u>Blueprints to guide investment</u>

First of all, indices are investment blueprints. It means that investments managers no longer have to each create their own investment strategies based on the data they collected to implement it. Indices provide an economy of scale by gathering the needs of similar investment strategies seekers. It is cheaper for them to retrieve the information from those indices instead of looking them up individually. The cost is consequently divided among them. Through this methodology, a fund can simply replicate the performance of a financial index by using the same composition strategy.

Moreover, it has the potentiality of decreasing the costs associated with governance and monitoring. While each investment manager acts differently and can be influenced by its own human characteristics, index fund manager must be transparent. They have the particularity of being held to provide expense ratios and proofs of the quality of their strategy. This way, we can compare easily their performances as the return demonstrated by an index fund manager should be similar to the performances of others tracking the same index. The competition driven from this return chase should assure the managers' discipline.

b) Contract referents

On the other hand, indices can be useful as contract referents. When setting the terms of a contract, opportunism may arise as the market price are fluctuating. The same way that indices represent blueprint for funds, they can be seen as references for contracts. Instead of guessing the future fluctuations of the market and the price that will result, parties can decide to follow an index and hence to reduce the cost associated with their researches. The coordination between the different parties is thus more efficient and the investing instruments can be more sophisticated and precise.

c) Information sources

Finally, indices are a huge source of information. They provide more transparency for the market and improve them. Indeed, while the cost of research for the price of a commodity in different markets is to be considered, so is the cost of research for its price evolution. Indices act here as a gathering of information to decrease the likelihood of the tragedy of commons[11]. They avoid the duplicative and time-wasting

[11] As defined by Hardin (1968): "*The tragedy of the commons is a situation in a shared-resource system where individual users acting independently according to their own self-interest behave contrary to the common good of all users by depleting or spoiling that resource through their collective action.* "

aspect of this research. Index providers thus share information to the market at a lower cost for all.

Another way through which information is shared is regarding the individual knowledge. Each person has private information about its willingness to sell and buy a commodity, or about the supply of it, etc. and can benefit from not sharing this information with other market participant. The liquidity and diversification provided by indices retrieved the information from the traders.

But while indices provide a wide range of benefits, they also come with risks. Some indices may be of poor quality or manipulated and show unexpected results. But different types of indices exist and with their own characteristics come their own risks and likelihood of happening (Hoffmann & Busch, 2008). To mitigate that risk Rauterberg and Versteint (2013) highlight two elements. The first one is the fact that in order to keep its clients, product index providers must be competitive and thus guarantee a good product quality. It can be either strengthened or weakened by the cost that clients have to bear to switch to another index. On the other hand, contracts may also protect those clients from unreliable indices by freeing them. Nevertheless, those clauses are quite rare and difficult to invoke.

3.2. Responsible indices

The previous sections helped us understand the use of sustainable criteria both in business and in investments. After reviewing general theory on indices, we can combine those two areas to focus on sustainable indices. While it is difficult to determine the extra-financial value of responsible investments, indices provide us each with their own guidelines and benchmarks. As explained before, the selection of the securities that will be part of the index is ruled by both inclusion and exclusion criteria.

The first family of global sustainable index are the Dow Jones Sustainability Indices (DJSI) that was created in 1999. They're based on a best-in-class methodology that assesses the best performing companies in term of ESG. While they each have their area of focus in terms of industry and region, they all are based on the assessment made by RobecoSAM.

This investment specialist takes a starting universe of approximately 10 000 companies from the S&P Global BMI. After proceeding to a float-adjusted market capitalization selection (e.g. p.31), RobecoSAM evaluates each year over 4500 global market-cap leaders on ESG criteria. Its Corporate Sustainability Assessment (CSA) provides a score for the selected companies. The ESG criteria evaluated are quite broad, the analysis is thorough, and scores are given for each dimension: Environment, social and governance. Then the top 10 to 30 % scoring companies are included in the appropriate index (Appendix 3). Details of the methodology implemented by RobecoSAM are given in appendix 4 and 5. RobecoSAM also highlights four sustainability awards: Gold is given to companies scoring at least 60 out of a maximal score of 70, and that are in the top 1% of their industry. For Silver they must score at least 57 and be in the top 1 to 5%, while bronze aims at least 54 for the 5 to 10%best. Finally, the best industry mover award is given to the company that has achieved the largest proportional improvement in its sustainability performance compared to the previous year while being part of the top 15% (RobecoSAM, 2019).

Nowadays, many indices have followed this path. The most famous with the Dow Jones' family are the FTSE4Good Index Series, and the MSCI ESG Indexes. The figure below compares the methodology they each use.

INDICES SERIES	INCEPTION	ESG ANALYSIS	METHODOLOGY	EXCLUSIONS	DISCLOSURE OF INDEX COMPONENTS
Dow Jones Sustainability Indices	1999	RobecoSAM	Best-in-class		No, ten first positions and leaders of each sector
FTSE4 Good Index Series	2001	Eiris	Tailor-made Analysis	Arms, nuclear energy and tobacco	No, list of biannual entry and exit
MSCI ESG Indices	2010	MSCI	Best-in-class	For the SRI Serie: alcohol, arms, firearms, nuclear energy, gambling, GMO, pornography, tobacco	No, ten first positions

Figure 10: Main SRI index families worldwide[12]

Nevertheless, it is important to note that while those indices provide an easy way to follow SRI trends, they are mostly used by rating agencies to encourage companies to go

[12] https://www.novethic.com/fileadmin/user_upload/tx_ausynovethicetudes/pdf_complets/2014_passive_management_report.pdf

the sustainable way. Only a few ETFs, representing about €1.2 billion of Assets under Management in 2013, actually replicate those indices. This amount accounts for less than 0.1% of ETF AuM globally (Novethics, 2014).

Nevertheless, the specific demand for low carbon has been rising recently. Customized indices started to appear with two major types. The first one is based on divestment of holdings in the fossil fuel sector, promoting ex-fossil fuel indices while the second one focuses on a multi-sector approach and a low carbon economy (Novethics, 2019).

While it is crucial to understand the ESG trend in investments and in particular in indices, we decided to focus our analysis on low carbon indices. Two reasons can be highlighted. The first one is that many contributions have already been made to the literature on ESG performances. The second one is the fact that environmental issues are seen as the most urgent area of concern as it will soon be too late to reverse the negative trend impacting other areas. Furthermore, the theoretical content we have exposed can easily be applied to the narrowed focus of environment and more precisely low carbon emissions.

III. EMPIRICAL CONTENT

As stated earlier, the objective of this thesis is to compare the performance of low carbon indices with the performance of regular ones. In order to conduct this analysis, we will first review the data that we used, then explain the methodology we chose to follow.

The methodology first explains the different step relating to both the statistic analysis of our indices and the performance analysis conducted on them. Finally, we will go through the results obtained. The analysis will be performed on the variation of the indices' values as it is a good measure of their performance. Indeed, we argued in the theoretical section (e.g. p.30) that the value of the indices matters less than their fluctuations as they can be calculated with different methodologies.

1. DATA

In order to compare low carbon indices and regular ones, two sets of data are necessary: one for the low carbon indices and one for the traditional indices. While the universe of low carbon indices is quite recent and still growing, it is interesting to focus our analysis on this type of index to really capture the effect of that particular criteria. We will, therefore, select 12 random low carbon and 12 random traditional indices. We collected data on the values of those indices from February 2011 to August 2018 on a monthly basis.

The indices represent different parts of the world including: North America, Europe, Japan, Emerging countries, a combination of emerging and developed countries and finally the world. The location criteria will allow us to classify the indices and to compare them by region. We notice that our universe doesn't count any low carbon indices in emerging markets. It will thus be interesting to analyze the results of traditional indices of this region to capture the differences of this market.

The indices can be categorized as in table 3:

	World	US (+ Canada)	Europe	Japan	Emerging Markets	ACWI[13]
Low Carbon	M1CXSGC; NG720289; NU720289; M1WOLCL	SXUCSER	SXXCDST ; SXXCSET ; SXXCDSR ; SXXCSER	M4CXJLC	/	M1WDLCL ; M1WDLCT
Traditionals	MDWO; NDDUWI	NDDUUS ; SXUSV ; NDDUNA[14]	SXXR; NDDUE15; SX5U; SX5T	NDDLJN	NDUEEGF	NDUEACWF

Table 3:Indices by region

In order to be able to have a thorough comparison, the two following tables (table 4 and 5) give a deeper insight on each index. It shows basic information such as the number of companies included in the index, some financial components and the sectors and countries represented. While our analysis concentrates mostly on the comparison between low carbon indices and traditional ones, some differences are due to variations in those factors rather than on the CO_2 emissions.

[13] ACWI stands for "All Country World Index" and gathers indices on both emerging and developed markets, the list of these countries can be found in appendix 6.
[14] This index includes Canada

		LOW CARBON											
		M1CXSGC	M1WDLCL	M1WDLCT	M1WOLCL	NU720289	M4CXJLC[16]	NG720289	SXUCSER	SXXCDSR	SXXCDST	SXXCSER	SXXCSET
Info	# of components	1276	2084	1851	1290	422	NA	430	50	50	50	50	50
	Dividend	2.42	2.47	2.44	2.45	2.59	NA	2.52	3.7	4.3	4.3	4.6	4.1
	P/E	18.57	17.62	17.83	18.19	15.93	NA	14.86	22.6	15.2	18.4	15.6	14.7
	P/book	2.48	2.33	2.37	2.43	2.11	NA	2.19	2.3	2.1	1.7	1.5	1.4
Sectors	Financial	17.19	18.2	18.58	17.41	12.74	NA	11.76	28	25,7	18.8	54.7	39.6
	IT	16.33	16.26	16.21	16.76	21.01	NA	19.76	/	/	/	/	/
	Communication	8.48	9.1	8.9	8.86	5.05	NA	6.48	/	12.6	10.6	10.4	7.1
	Healthcare	12.05	11.19	10.93	12.18	9.74	NA	12.67	/	3.8	3.8	2.3	/
	Energy[17]	4.17	5.33	4.16	4.96	4.76	NA	2.92	/	/	3.8	1.7	5.7
	Utilities	2.91	3.52	2.88	3.69	4.39	NA	4.91	21.6	21.7	26.4	17	16.6
	Materials	3.71	4.64	3.66	4.14	3.2	NA	5.01	/	/	/	/	/
	Industry	12.67	9.95	11.97	11.21	13.72	NA	13.57	12.4	10.1	10.2	5.4	11.6
	Consumer goods	19.34	18.82	19.45	17.44	18.46	NA	17.78	4.2	9.8	6	/	5.6
	Retail	/	/	/	/	/	NA	/	5.4	3.8	3.4	1.7	/
	Real estate	3.16	2.99	3.26	3.35	6.94	NA	5.15	9.8	2.4	/	/	/
	Automotive	/	/	/	/	/	NA	/	/	/	/	3.4	3.4
	Chemicals	/	/	/	/	/	NA	/	3.4	/	/	1.9	3.4
	Others	/	/	/	/	/	NA	/	4.4	6.2	6.6	/	/
Countries	US	62.67	54.89	55.34	61.98	57.77	/	58.88	100	/	/	/	/
	UK	5.61	5.13	4.93	5.55	7.2	/	6.59	/	24.6	/	21.6	/
	France	3.94	3.5	3.56	4.12	6.12	/	5.8	/	10.6	23	10.5	23.9
	Germany	/	/	/	/	/	/	/	/	14	17.9	16	26.6
	Switzerland	/	/	/	/	/	/	/	/	9.2	/	10.4	/
	Italy	/	/	/	/	/	/	/	/	6.9	7.3	6.8	6.7
	Finland	/	/	/	/	/	/	/	/	8.2	10	5.9	9.3
	Spain	/	/	/	/	/	/	/	/	6.6	18.8	4.6	14.2
	The Netherlands	/	/	/	/	/	/	/	/	4.8	8.4	6.1	11.7
	Belgium	/	/	/	/	/	/	/	/	/	6.4	4.6	4.5
	Canada	3.64	/	/	3.97	/	/	/	/	/	/	/	/
	Japan	8.03	7.21	7.07	8.22	5.48	100	6.14	/	/	/	/	/
	China	/	3.84	3.92	/	/	/	/	/	/	/	/	/
	Australia	/	/	/	/	5.51	/	5.2	/	/	/	/	/
	Others	16.1	25.43	25.18	16.15	17.93	/	17.39	/	15.1	6.7	5	3.1

Table 4:Information on indices from our low carbon universe[15]

[15] All numbers are percentages except for the number of components.
[16] We don't have deeper information on this index' composition.
[17] Specified as counting only oil & gas are marked in red.

		TRADITIONALS											
		NDDUWI	NDUEACWF	SXUSV	SX5U	MDWO	NDUEEGF	NDDUE15	NDDUNA	NDDLJN	NDDUUS	SX5T	SXXR
Info	# of components	1636	2774	50	50	1636	1138	440	715	322	624	50	600
	Dividend	2.44	2.47	2.6	3.05	2.44	2.66	3.64	1.98	2.39	1.92	2.7	3
	P/E	18.35	17.63	22.3	17.89	18.35	13.57	15.7	20.77	13.04	20.96	16.9	16.4
	P/book	2.46	2.33	0	1.48	2.46	1.66	1.81	3.33	1.28	3.48	1.6	1.7
Sectors	Financial	16.1	17.04	12.9	32.1	16.1	24.18	18.85	14.42	10.85	13.08	17.6	16.4
	IT	16.32	16.14	32.8	4.3	16.32	14.77	5.74	21.31	11.13	22.19	10.3	5.2
	Communication	8.42	8.9	3.8	9.9	8.42	12.51	4.74	9.97	8.66	10.35	/	/
	Healthcare	12.1	11	12.8	3.4	12.1	2.65	12.38	12.81	8.77	13.4	9.1	13.9
	Energy[19]	5.86	6.1	4.7	9.4	5.86	7.94	8.03	5.93	0.96	5.14	6.7	7
	Utilities	3.27	3.18	/	11.5	3.27	2.47	4.04	3.11	1.83	3.15	4.6	4.1
	Materials	4.49	4.8	/	/	4.49	7.12	7.54	3	5.6	2.67	/	/
	Industry	11.22	10.52	6.5	5.1	11.22	5.23	13.39	9.44	21.41	9.44	10.9	10.9
	Consumer goods	19.07	19.18	4.2	3.2	19.07	20.04	14.22	17.12	9.81	17.59	10.9	8.5
	Retail	/	/	11	1.2	/	/	/	/	/	/	/	/
	Real estate	3.15	3.14	/	/	3.15	3.1	1.44	2.89	3.98	3.01	/	/
	Automotive	/	/	/	2.4	/	/	/	/	/	/	/	/
	Chemicals	/	/	/	6	/	/	/	/	/	/	8.2	4.2
	Others	/	/	3.7	11.3	/	/	/	/	/	/	4.5	7.5
Countries	US	62.71	55.43	100	/	62.71	/	/	94.84	/	100	/	/
	UK	5.75	5.08	/	/	5.75	/	26.85	/	/	/	/	26.7
	France	3.88	3.43	/	34.9	3.88	/	18.13	/	/	/	38.6	17.2
	Germany	/	/	/	26.2	/	/	14.11	/	/	/	31.4	14.3
	Switzerland	/	/	/	/	/	/	13.84	/	/	/	/	14
	Italy	/	/	/	11.2	/	/	/	/	/	/	4.8	3.9
	Finland	/	/	/	2.4	/	/	/	/	/	/	1	/
	Spain	/	/	/	16.3	/	/	/	/	/	/	10	4.6
	The Netherlands	/	/	/	5.2	/	/	4.78	/	/	/	10.4	5.1
	Belgium	/	/	/	1.4	/	/	/	/	/	/	2.7	1.8
	Canada	3.41	/	/	/	3.41	/	/	5.16	/	/	/	/
	Japan	8.03	7.1	/	/	8.03	/	/	/	100	/	/	/
	China	/	3.84	/	/	/	33.04	/	/	/	/	/	/
	Australia	/	/	/	/	/	/	/	/	/	/	/	/
	Others	16.21	25.12	/	2.4	16.21	66.96	21.29	/	/	/	1	7.1

Table 5: Information on indices from our traditional universe[18]

[18] All numbers are percentages except for the number of components.

[19] Specified as counting only oil & gas are marked in red.

2. METHODOLOGY

The first step to conduct our analysis is to test several hypotheses on our data sets. In this scope, we will first perform statistical tests that will give us a general idea on the data. Afterward, we'll be able to take a look at the performance of the indices. The methodology will therefore by composed of two part.

The statistical tests will determine whether the returns of the indices follow a normal distribution. This is particularly important because the performance tests that will come after are considered more efficient on normal distributions. Different tools will guide us starting by a global overview of the behavior of the returns, followed by Jarque-Bera tests and quantile-quantile graph that will allow us to make a visual comparison. Thereafter, we will verify the existence of an autocorrelation on each index before looking for correlation among them. The correlation tests will be performed on indices of the same universe and then mixing our low carbon and traditional universes. A t-test will finally allow us to check a possible equality of mean on average between indices of the same region but from different sets.

On the second hand, performance tests will give us a concrete answer to our research question. The results will be shown through the general evolution of the returns and through cumulative returns during our period range. Each index will be considered, and comparisons will be made between regions. Thanks to the CAPM and the FAMA-FRENCH model we will be able to assess concretely the performance of each index. Finally, several ratios (namely: the Sharpe ratio, the Treynor ration, the Sortino ratio and the Information ratio) will conclude our analysis. The theoretical details of each test are presented in appendix 7.

3. *RESULTS*

3.1. *Statistical test*

We can develop hypotheses on those indices' returns and test them. First, we can check if our indices' returns follow a normal distribution. This aspect is important because the regressions that we will perform on our data sets will indicate more precise results if the returns are characterized by a normal distribution without autocorrelation.

3.1.1. Global overview

First, we can compare the statistic results of our two types of index. The table below shows the statistical results of the indices' returns:

	Low Carbon											
	SXUCSER	SXXCDSR	SXXCDST	SXXCSER	SXXCSET	M1CXSGC	M1WDLCT	M1WOLCL	NU720289	M4CXJLC	NG720289	M1WDLCL
Observations	90											
Minimum	-0.0483	-0.0819	-0.0847	-0.0717	-0.0873	-0.0871	-0.0943	-0.0877	-0.0754	-0.1053	-0.0557	-0.0928
Mean	0.0109	0.0069	0.0064	0.0067	0.0055	0.0077	0.0071	0.0079	0.096	0.093	0.0120	0.0072
Maximum	0.0797	0.0808	0.0766	0.0827	0.0799	0.1034	0.1064	0.1029	0.1072	0.1264	0.0774	0.1063
Std Dev	0.0261	0.0288	0.0312	0.0295	0.0331	0.0333	0.0341	0.0335	0.031	0.0481	0.0272	0.0342
Skewness	0.0772	-0.4353	-0.2956	-0.1585	-0.2292	-0.3165	-0.3296	-0.3242	-0.205	-0.105	-0.2935	-0.3234
Kurtosis	0.2138	0.5076	0.1754	-0.0074	-0.1632	0.98	1.1746	0.9664	0.9305	0.1967	0.1868	1.1632
	Traditionals											
	MDWO	NDDLJN	NDDUE15	NDDUNA	NDDUUS	NDDUWI	NDUEACWF	NDUEEGF	SX5T	SX5U	SXXR	SXUSV
Observations	90											
Minimum	-0.0629	-0.1056	-0.1226	-0.0793	-0.0724	-0.0864	-0.0944	-0.1458	-0.1370	-0.1354	-0.0656	-0.1027
Mean	0.0099	0.0089	0.0045	0.0097	0.0104	0.0076	0.007	0.0027	0.0048	0.0034	0.0107	0.0063
Maximum	0.0775	0.1269	0.1210	0.1089	0.1094	0.1034	0.1071	0.1325	0.1034	0.1383	0.0982	0.0808
Std Dev	0.0281	0.0483	0.044	0.0312	0.0311	0.0332	0.0341	0.0487	0.0438	0.0537	0.0305	0.0345
Skewness	-0.2042	-0.1228	-0.2262	-0.1491	-0.0955	-0.3184	-0.3284	-0.0588	-0.3253	-0.1322	-0.0424	-0.4638
Kurtosis	0.1695	0.1977	0.3338	1.025	0.8807	1.0096	1.2166	0.8276	0.1809	-0.1767	0.3592	0.4815

Table 6: Global overview of indices' performance

It is interesting to notice that the average returns for both index types are non-negative over this period range. The lowest minimal return has been hit by traditional indices but so has the highest maximal return. Which is consistent with the fact that traditional indices present a higher standard deviation. Moreover, the lowest mean is presented by a traditional index while the highest one is from the low carbon universe.

Finally, if we take a look at the shape of the distribution of each data set, we can highlight the negative sign of all the distributions' skewness (except for SXUCSER index). This can be translated by a longer left tail meaning that the mass of the distribution is concentrated on the right of the figure. As a consequence, we will observe frequent small upsides and rare extreme downsides. On the other hand, most of the kurtosis are positive and show that the distribution has fatter tails than a normal distribution. It can be translated as a higher probability of big positive and negative returns than in a normal distribution. Distributions presenting negative kurtosis have lighter tails than a normal distribution. The best distribution of returns for an investor would be one that has a higher skewness while keeping lower standard deviation and kurtosis – like it is the case for the NG720289 index for example. The shape of each index' returns distribution can be found in appendix 8.

3.1.2. Normal distribution

The Jarque-Bera tests performed on our indices give us a better insight regarding the distribution of returns for each index. It is used in statistics to verify whether a sample data has the skewness and kurtosis matching a normal distribution. The results given by the p-values are shown in detail in appendix 9. Only three indices indicate values that don't allow us to conclude that the returns follow a normal distribution. Those indices are: M1WDLCT, M1WDLCL and NDUEACWF. As a consequence, we must mitigate the results that we will find for these indices.

Quantile-Quantile graphs of each of the indices can be found in appendix 10. They have been provided in order to confirm the fatter tails of the distribution of traditional indices' returns.

3.1.3. Autocorrelation

The analysis of autocorrelation allows to find repeating patterns. It can be a signal for periodic trend obscured by noise for example. In the case of a positive autocorrelation with a value of 1, we can conclude that the series are perfectly and positively correlated, while a negative autocorrelation with a value of -1, shows that the series are perfectly and negatively correlated (Smith, 2019). The graphs resulting from this analysis are displayed in appendix 11. They show that no autocorrelation was found on our data sets. We can consequently conclude that there is no link between past returns and future returns.

3.1.4. Equality of mean

Several paired t-tests were performed to verify the equality of the means between traditional and low carbon indices of the same region. It shows that all p-values are high and therefore indicates that the average returns of the two types of indices of the same region don't differ significantly. The detailed results are displayed in appendix 12.

3.1.5. Correlation

In statistics, the correlation represents a statistical relationship, whether causal or not, between two random variables or bivariate data. It shows the degree of linear relationship between two variables and indicates if this relationship can be used in practice. In our analysis it will allow us to determine if a link exists between the performance of our low carbon indices and the performance of the traditional ones but also between indices of the same universe. Moreover, it will indicate the level of this possible relationship. A high correlation value, whether it's positive or negative, means that the performance of the indice can mostly be explained by the performance of the indice it is correlated to, while a low value means that there is no link between the performances of the two indices.

If we take a closer look at the correlation of our indices, we can differentiate three parts: the correlation between low carbon indices, the correlation between traditional indices and finally the correlation between low carbon and traditional indices.

The graphs presenting those correlations can be found here under:

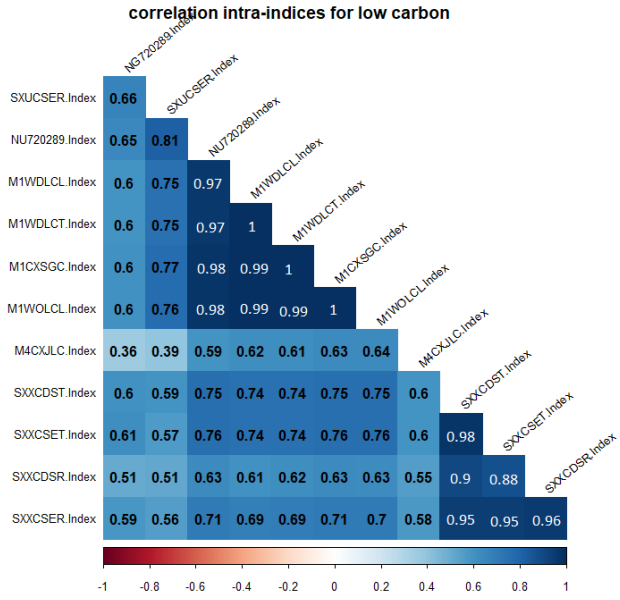


Figure 9: Intra-indices correlation for low carbon universe

First, we see that all correlations are positive. Two highly correlated part are visible. The first one focuses on the European indices while the second one gathers the world and the ACWI indices. This makes perfect sense as they operate mostly on the same countries and have similar sector investments. The same acknowledgement can be made in lower proportion on the correlation between world indices and the European or North American ones. Finally, M4CXJLC, our Japanese index is less correlated with the others.

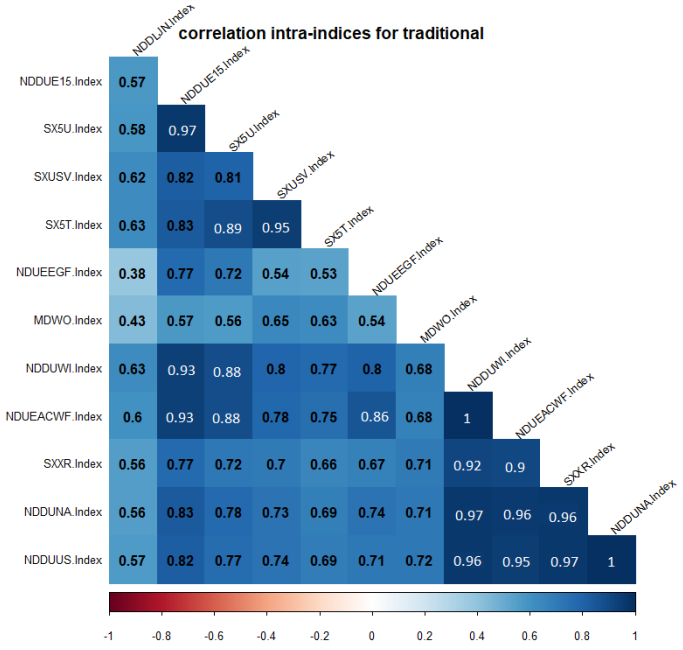


Figure 10: Intra-indices correlation for traditional universe

Here again, the Japanese index (NDDLJN) shows a lower correlation with the rest of the market. High correlations are found on indices of the same region especially for European and world indices. The lighter correlation is spotted between emerging markets and the Japanese index. There, in addition of different countries, we can mention the difference between the sectors they are focusing on (e.g. p.39).

Finally, we can aggregate those two matrices in order to verify if correlation between our two universes of indices exist:

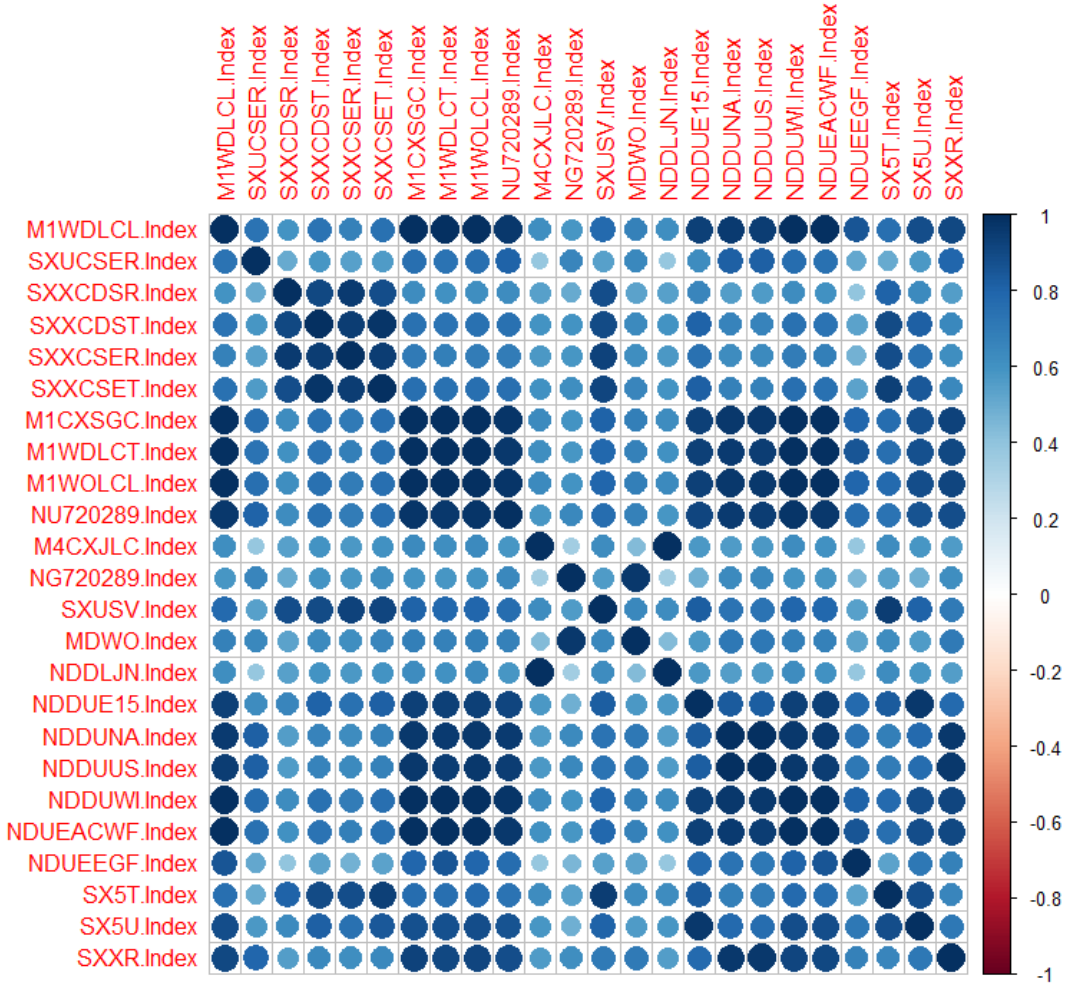


Figure 11: correlation between low carbon and traditional indices

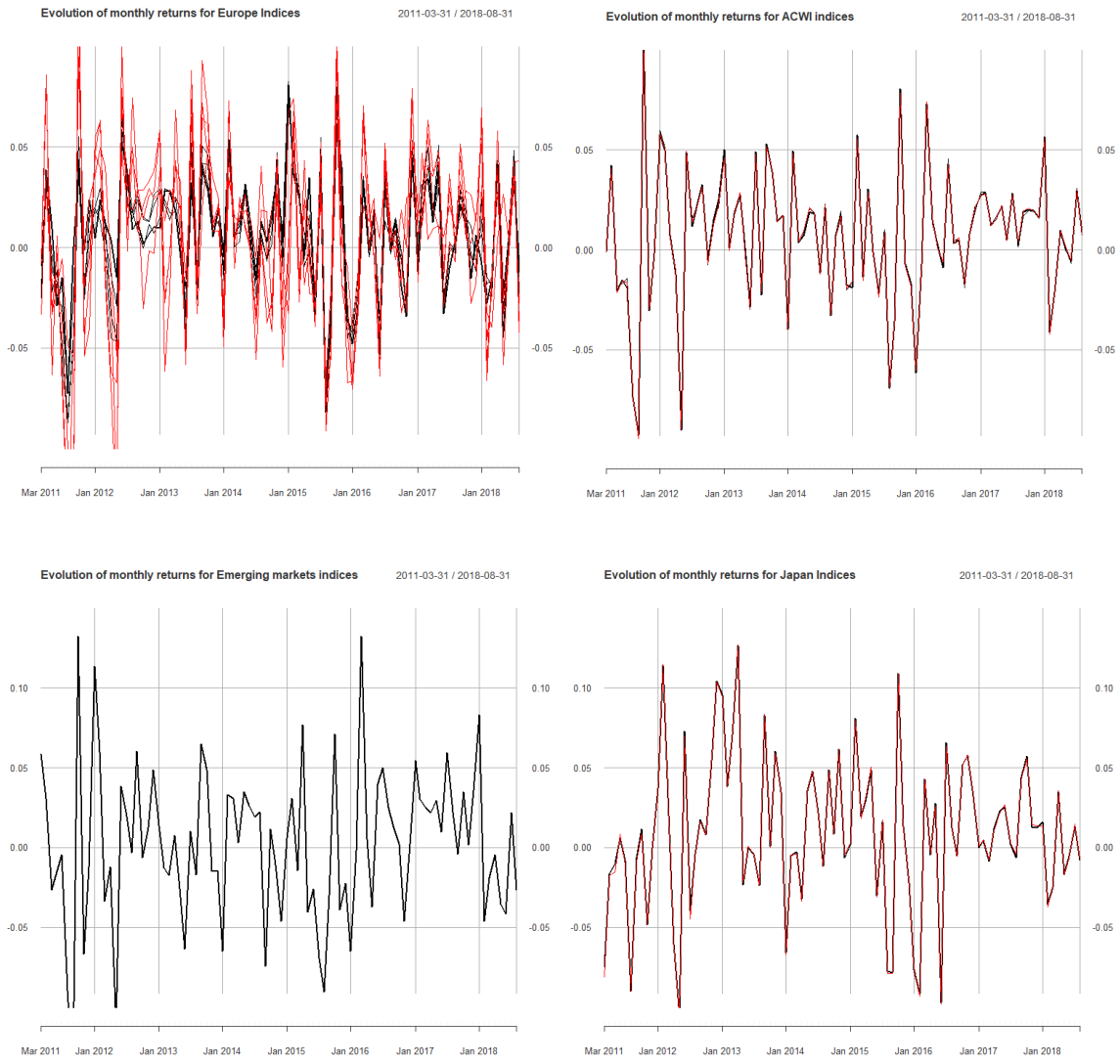
While looking at the correlation between low carbon and traditional indices, we can extend the conclusions we made before. Indices from the same region are highly correlated even when they are part of different sets. Surprisingly, the MDWO and the NG720289 – both global indices - are not much correlated with their counterparts.

3.2. Performance analysis

Now that we have a global view of the way our indices' returns are distributed and interacting with each other, we can focus on their performances. This section will provide an analysis of the performance of each index during our period range.

3.2.1. Global overview

We first analyze the evolution of the monthly returns for our indices. The graphs of these evolutions are displayed by region. They show that in each case, most indices follow the same trend. Moreover, we can see that traditional indices tend to react more strongly. This is the result of their higher volatility. It is especially the case of the emerging markets index as mentioned in the global overview.



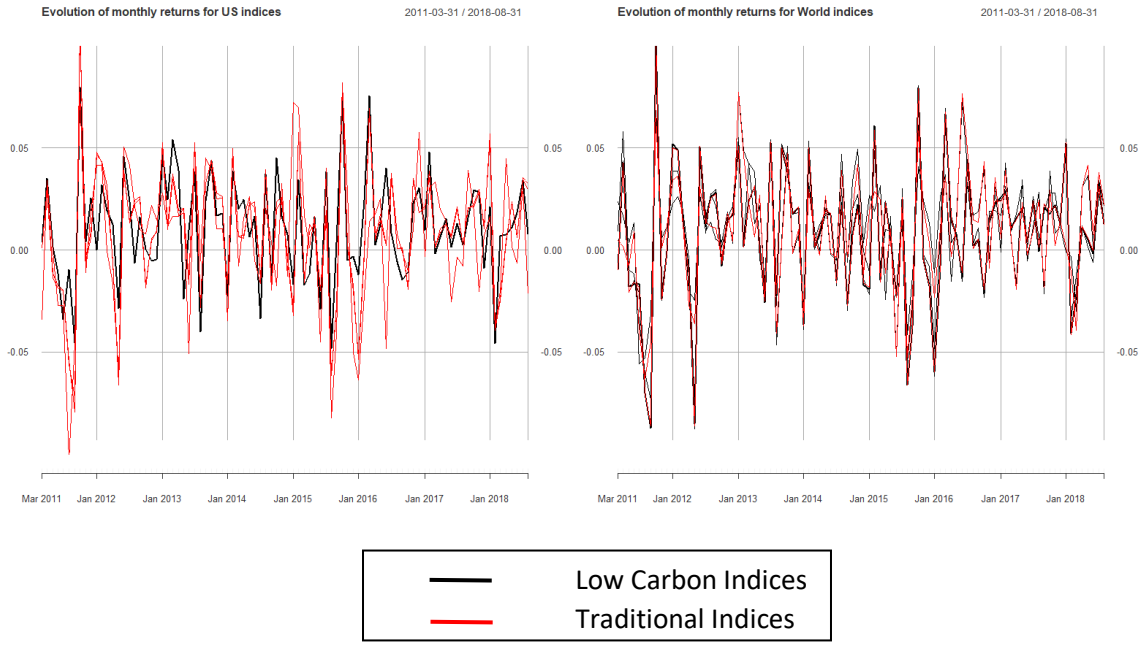


Figure 12: Evolution of monthly returns by region

While the monthly returns go up and down through time, we can get a more global and clear view thanks to the cumulative returns.

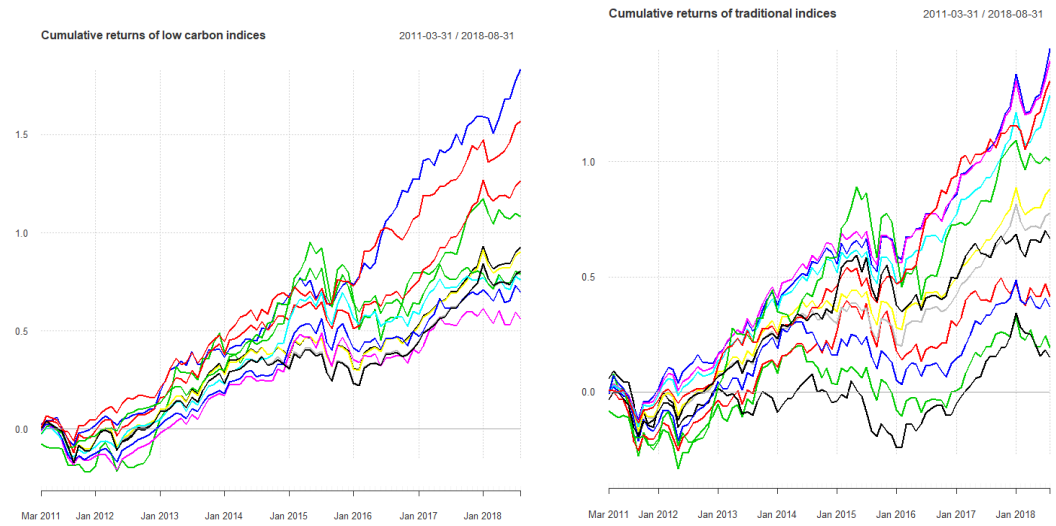


Figure 13: Evolution of cumulative returns for low carbon and traditional indices

The two graphs above show the cumulative returns for low carbon and traditional indices. We can already see that some low carbon indices go higher (up 1.5%). The detailed graphs for each index are displayed in appendix 13 and present strong similarities by regions. We note that the flattest and highest cumulative returns are performed by the NG720289 index.

We can then aggregate the low carbon indices between them and do the same for traditional indices before comparing them. It produces a graph where we can clearly see the difference between low carbon and traditional indices' cumulative returns. It demonstrates that on a seven years period (from 2011 to 2018), while they have been following the same trend, the low carbon indices present in our universe have been performing better than the traditional ones as in the figure below:

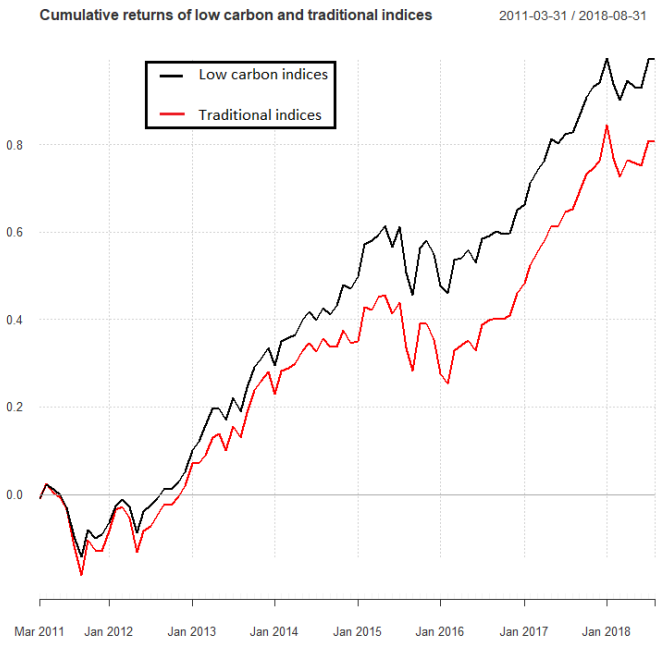


Figure 14: Cumulative returns of low carbon and traditional indices universes

3.2.2. The CAPM

The Capital Asset Pricing Model is used to describe the relationship between the market risk and expected return of an asset. It allows to put a price on a security matching with the expected returns. Thanks to this model we can introduce the Jensens' Alpha which represents the difference between the actual return of an asset and the one predicted by the CAPM. It, therefore, indicates the risk-adjusted performance of the asset.

The Beta, on the other hand, measures the volatility, of a specific security in comparison to the unsystematic risk of the market. In order to capture this difference, the beta is calculated thanks to the covariance between the asset's return and the market's return.

Additionally, we will use the R^2 to assess the proportion in which the model is adapted to explain the results. A bigger R^2 means a better model. The R^2 of the CAPM and the FAMA-FRENCH that we will perform will show the percentage of returns that can be explained by the indices of reference. Applying the CAPM on our two data sets, we find the results displayed in table 7:

Low Carbon	Alpha		Beta		R^2	
	Estimates	P-Value	Estimates	P-Value	Estimates	P-Value
SXUCSER	0.003951	0.0494	0.571730	<2e-16	0.5257	< 2.2e-16
SXXCDSR	0.0003224	0.9	0.5182776	2.87e-10	0.3555	2.87e-10
SXXCDST	-0.001551	0.506	0.685935	<2e-16	0.5377	< 2.2e-16
SXXCSER	-0.000392	0.871	0.5980516	1.71e-13	0.4512	1.711e-13
SXXCSET	-0.002732	0.27	0.734343	<2e-16	0.5432	< 2.2e-16
M1CXSGC	-0.002723	3.47e-05	0.9839692	< 2e-16	0.9706	< 2.2e-16
M1WDLCT	-0.003666	2.43e-07	1.0049146	< 2e-16	0.969	< 2.2e-16
M1WOLCL	-0.002629	2.01e-05	0.9926505	< 2e-16	0.9747	< 2.2e-16
NU720289	-9.985e-05	0.915	8.937e-01	< 2e-16	0.9245	< 2.2e-16
M4CXJLC	-0.000399	0.923	0.8671354	8.18e-11	0.3727	8.182e-11
NG720289	0.005707	0.0203	0.471540	1.06e-09	0.3371	1.057e-09
M1WDLCL	-0.003635	4.33e-08	1.0104839	< 2e-16	0.9736	< 2.2e-16
Traditionals	Alpha		Beta		R^2	
	Estimates	P-Value	Estimates	P-Value	Estimates	P-Value
MDWO	0.002898	0.208	0.564015	2.13e-13	0.4485	2.134e-13
NDDLJN	-0.000803	0.847	0.8673088	1.04e-10	0.3695	1.037e-10
NDDUE15	-0.007923	1.03e-05	1.232753	< 2e-16	0.8759	< 2.2e-16

NDDUNA	0.000081	0.939	0.887288	< 2e-16	0.9032	< 2.2e-16
NDDUUS	0.0008497	0.461	0.8749461	< 2e-16	0.8857	< 2.2e-16
NDDUWI	-0.00284	5.92e-06	0.9845018	< 2e-16	0.9738	< 2.2e-16
NDUEACWF	-0.003761	3.83e-08	1.0061923	< 2e-16	0.9718	< 2.2e-16
NDUEEGF	-0.010240	0.00138	1.161755	< 2e-16	0.6519	< 2.2e-16
SX5T	-0.005525	0.081	0.989199	< 2e-16	0.5712	< 2.2e-16
SX5U	-0.01027	0.000361	1.419537	< 2e-16	0.7779	< 2.2e-16
SXXR	-0.002836	0.231	0.807722	< 2e-16	0.6113	< 2.2e-16
SXUSV	0.007707	0.0253	-0.038426	0.6935	0.001714	0.6935

Table 7: Result of the CAPM on indices

We note that not all p-values are inferior to 5%. Several alphas as well as the beta and R^2 of the SXUSV index cannot be interpreted. Two alphas of the low carbon indices and one of the traditional ones are positive which indicates that they outperform the market on this period. Our traditional indices tend to have a higher beta than low carbon ones. It relates once again that they are more volatile and in the case of beta higher than 1, they also are more volatile than the market. It may be interesting to note that the highest beta is reached by SX5U (>1.4) which is the index that invest the most in the financial sector. We can also mention that the less volatile index (NG720289) presents the highest alpha- as shown previously by the cumulative returns. Regarding the R^2 the best values come from global indices. It was to be expected as the factors used for the CAPM are also global, it is normal that the model explains better the returns of those indices.

3.2.3. The FAMA-FRENCH model

The FAMA-FRENCH model is an extension of the CAPM. It was developed in order to take more factors into account while trying to price a security. The two additional factors relate to the size and the value of the companies. Indeed, studies (Hayes, 2019) have shown that small cap stocks are risker but also generate higher returns. SMB, therefore, accounts for publicly traded companies with small market caps that generate higher returns, while HML accounts for value stocks with high book-to-market ratios that generate higher returns in comparison to the market. Including these two factors will create a better model as it will adjust to outperformance trends. The results of the FAMA-FRENCH model applied to our data sets are displayed in table 8 below:

Low Carbon	Alpha		Beta		SMB		HML		R^2	
	Estimates	P-Value	Estimates	P-Value	Estimates	P-Value	Estimates	P-Value	Estimates	P-Value
SXUCSER	0.005306	0.00753	0.569510	<2e-16	-0.461211	0.0019	-0.085703	0.42791	0.5768	<2.2e-16
SXXCDSR	0.001744	0.4939	0.520402	1.19e-10	-0.434436	0.0235	-0.203360	0.1522	0.4038	4.959e-10
SXXCDST	-4.763e-05	0.9833	6.785e-01	<2e-16	-5.673e-01	0.0011	3.169e-02	0.8013	0.5906	<2.2e-16
SXXCSER	0.00139	0.552336	0.59445	2.59e-14	-0.61443	0.00062	-0.09552	0.461861	0.5212	3.246e-14
SXXCSET	-0.001007	0.670377	0.724526	<2e-16	-0.664967	0.00027	0.068909	0.599637	0.6084	<2.2e-16
M1CXSGC	-0.00213	0.000321	0.981724	<2e-16	-0.216223	1.77e-06	-0.005146	0.870821	0.9773	<2.2e-16
M1WDLCT	0.003274	2.1e-06	1.002865	<2e-16	-0.1491266	0.00249	0.0110436	0.7582 4	0.9721	<2.2e-16
M1WOLCL	-0.002141	0.00013	0.989488	<2e-16	-0.19251	5.33e-06	0.0292739	0.32660	0.9802	<2.2e-16
NU720289	0.0006158	0.494510	0.8939764	<2e-16	-0.22788	0.00095	-0.0814852	0.105274	0.9348	<2.2e-16
M4CXJLC	-0.0001838	0.9643	0.8449732	9.79e-11	-0.315561	0.3027	0.541896	0.0193	0.4179	1.743e-10
NG720289	0.007009	0.00469	0.470838	6.26e-10	-0.427632	0.0193	-0.118940	0.37719	0.3813	2.514e-09
M1WDLCL	-0.003325	2.2e-07	1.0073961	<2e-16	-0.134055	0.00303	0.0461469	0.16346	0.9766	<2.2e-16
Traditionals	Alpha		Beta		SMB		HML		R^2	
	Estimates	P-Value	Estimates	P-Value	Estimates	P-Value	Estimates	P-Value	Estimates	P-Value
MDWO	0.004036	0.0816	0.560131	1.59e-13	-0.409912	0.0181	-0.020571	0.8718	0.4823	1.007e-12
NDDLJN	-0.0006134	0.8821	0.8447121	1.22e-10	-0.3123992	0.3105	0.5555692	0.0172	0.416	2.006e-10
NDDUE15	-0.007057	4.4e-05	1.22345	<2e-16	-0.382363	0.00233	0.146019	0.11242	0.8914	<2.2e-16

NDDUNA	0.000778	0.45754	0.886736	<2e-16	-0.230789	0.00372	-0.059156	0.3092	0.9128	<2.2e-16
NDDUUS	0.001701	0.12912	0.87514	<2e-16	-0.27227	0.00139	-0.094375	0.129	0.9002	<2.2e-16
NDDUWI	-0.002289	4.16e-05	0.98157	<2e-16	-0.21021	7.27e-07	0.016789	0.57	0.9802	< 2.2e-16
NDUEACWF	-0.003396	2.48e-07	1.003335	<2e-16	-0.149356	0.00135	0.034445	0.3097	0.9752	<2.2e-16
NDUEEGF	-0.011309	0.000559	1.15799	<2e-16	0.302754	0.200179	0.208134	0.23797	0.6632	<2.2e-16
SX5T	-0.003503	0.2297	0.967304	<2e-16	-0.894965	7.31e-05	0.34535	0.0343	0.6576	<2.2e-16
SX5U	-0.008831	0.000794	1.396766	<2e-16	-0.716937	0.000266	0.428816	0.00309	0.8256	<2.2e-16
SXXR	-0.001457	0.53050	0.800267	<2e-16	-0.527223	0.00286	0.045093	0.7262	0.6491	<2.2e-16
SXUSV	0.008187	0.0214	-0.042283	0.6678	-0.197690	0.4482	0.047794	0.8058	0.008978	0.8478

Table 8: Results of the FAMA-FRENCH model on indices

Here again, we will only consider the estimates that have p-values inferior to 5%, they are highlighted in grey. If we compare to the results of the CAPM, we find that the alphas have higher values and that an additional low carbon index has a positive alpha. We note that three out of the four outperforming indices are low carbon. All betas can be interpreted except for the SXUSV index. They are globally reacting the same way in the CAPM. All SMB values are negative which can be translated by a higher sensitivity to big market capitalizations, especially for indices counting less components. Very few HML factors can be interpreted (one for low carbon and three for traditional indices). Their positive character show that the indices are relying on the value premium by investing in stocks with high book-to-market ratios to earn an abnormal return. They indeed, present the lowest values for the P/book ratio[20]. Finally, most R^2 are very high which indicates a good performance of the model. It is lower for the Japanese market for example.

[20] We do not have the information for M4CXJLC

3.2.4. Ratios

We can now expose different ratios that will help us get a more precise view of our returns.

The first one is the Sharpe ratio. It is used to understand the return of an investment compared to its risk. The ratio is the average return earned in excess of the risk-free rate per unit of volatility or total risk.

The second ratio is Treynor's. It is based on the same principle as the Sharpe ratio: assessing the excess return generated for each unit of risk taken on by a portfolio. The difference between those two ratios is that Treynor's uses the beta instead of the standard deviation.

Another interesting expansion of the Sharpe ratio is the Sortino ratio. The difference here is that we differentiate harmful volatility from total overall volatility. In order to do this, we only use the asset's standard deviation of negative portfolio returns (the downside deviation) instead of the total standard deviation of portfolio returns. Thanks to this differentiation, the Sortino ratio helps address the issue caused by using total risk, or standard deviation. Indeed, upside volatility is beneficial to investors and isn't a factor most investors worry about. By focusing on the downside deviation, it gives a better view of a portfolio's risk-adjusted performance since positive volatility is a benefit (Kenton, 2019). The result can be interpreted the same way as the Sharpe ratio.

Finally, the information ratio (IR) measures a portfolio returns beyond the returns of a benchmark in comparison with the volatility of those returns. The benchmark is generally an index. This IR allows us to identify the consistency of the performance by incorporating a tracking error, or standard deviation component into the calculation. This tracking error shows whether the portfolio is consistently beating the index over time or not. A higher IR result means that the portfolio manager is achieving a higher return in excess of the benchmark, given the risk taken.

In table 9 we expose the different results of these ratios for each index:

LOW CARBON	Sharpe	Treynor	Sortino	Information
SXUCSER	0.354714	0.01657	0.6919	-0.00259
SXXCDSR	0.1808	0.01035	0.2683	-0.14639
SXXCDST	0.1566	0.00727	0.23599	-0.187667
SXXCSER	0.1771	0.00899	0.2766	-0.15946
SXXCSET	0.1251	0.00579	0.18667	-0.21364
M1CXSGC	0.1935	0.00669	0.3071	-0.495305
M1WDLCT	0.1675	0.0058	0.2603	-0.596518
M1WOLCL	0.1973	0.00681	0.3143	-0.499295
NU720289	0.2654	0.0094	0.3758	-0.1173
M4CXJLC	0.1625	0.0916	0.4473	-0.042976
NG720289	0.372	0.02166	0.2568	0.026466
M1WDLCL	0.1693	0.00585	0.6741	-0.628524
Average	0,21015	0,016398	0,35793	-0,255266
TRADITIONALS	Sharpe	Treynor	Sortino	Information
MDWO	0.2889	0.0146	0.5023	-0.046077
NDDLJN	0.1532	0.00867	0.2395	-0.05315
NDDUE15	0.0819	0.002996	0.1217	-0.32769
NDDUNA	0.2669	0.009566	0.4531	-0.092699
NDDUUS	0.2891	0.01046	0.50399	-0.028185
NDDUWI	0.1902	0.00657	0.3015	-0.54492
NDUEACWF	0.1649	0.00571	0.2562	-0.63979
NDUEEGF	0.0132	0.00056	0.01902	-0.29904
SX5T	0.0854	0.00388	0.1233	-0.194489
SX5U	0.0559	0.00217	0.0819	-0.216697
SXXR	0.1375	0.00601	0.2009	-0.20439
SXUSV	0.1167	-0.07525	0.1694	-0.090003
Average	0,15365	0,032895	0,247734	-0,22809

Table 9: Value of the different ratios on indices

As the results are quite similar on all indices, we will take a look at the average on both low carbon and traditional indices.

First of all, we should mention the fact that our restricted universes underperform risk-free investments for all ratios on all the indices in our data sets. Indeed, a Sharpe ratio smaller than 1 can be translated by a non-sufficient return for each additional unit of risk taken compared to a risk-free investment. The same conclusion can be drawn from the Treynor ratio. The Sortino ratios show that low carbon indices have a better return per unit of downside risk and the information ratio supports the conclusion that our universes globally underperformed the market. Those results are mitigated as they don't demonstrate significant difference between our two universes.

CONCLUSION

As a conclusion, we can say that this Master Thesis allowed us to gain knowledge on both sustainable and low carbon investments. While these areas are still growing, we could, nevertheless, gather substantial information regarding those matters.

Our objective was to understand the incentives and obstacles to invest in low carbon solutions and to compare their performance with the performance of traditional indices. Our analysis was executed on several indices from both universes and comparisons were made by regions. The results highlighted several key outcomes.

The first one is that only four of the indices used in this thesis outperformed the market on our period range. Nevertheless, three out of those four were low carbon indices. Secondly, indices from a same region tend to follow the same trend and to present correlated returns. Moreover, the traditional index focusing on emerging markets had the worst performances on the majority of our tests. Comparatively, the index showing the best results is global and comes from the low carbon universe.

Additionally, our analysis demonstrated higher cumulative returns on average for the low carbon indices. A lower volatility has also been exposed compared to traditional indices. A lower risk of unforeseen events could be responsible for those results.

While it is important to note that we performed our analysis on restricted sets of data and that, therefore, the results of this analysis cannot be generalized to all indices, they still are consistent. By proving that higher returns and lower volatility can be achieved through low carbon investments, we provide an additional incentive to investors.

However, we chose to focus on low carbon as it was said to be the most important aspect of a global sustainable development. Further analysis on different areas of ESG investing could complete our results in the future.

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APPENDIX

APPENDIX 1: The sustainable development goals[21]

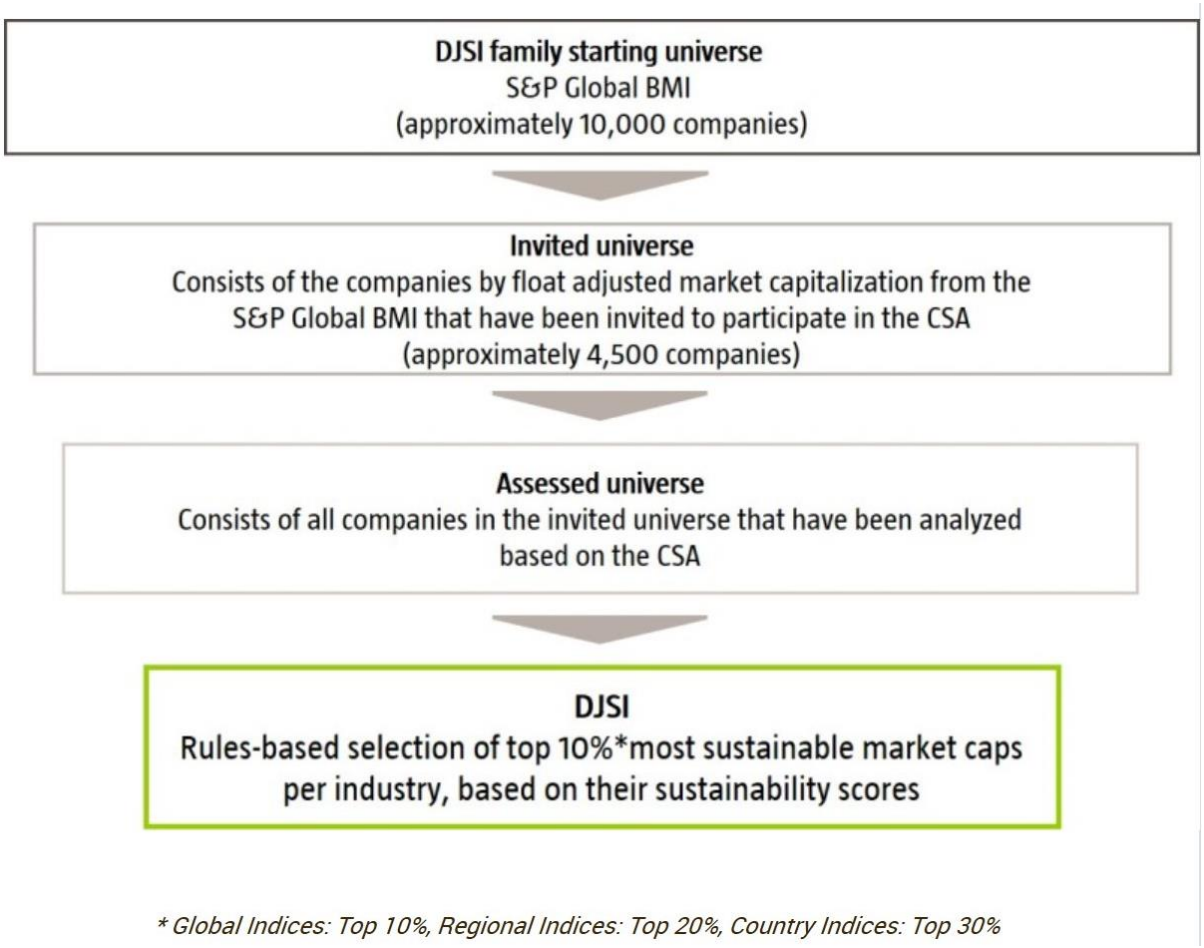
[21] https://www.un.org/sustainabledevelopment/blog/2015/12/sustainable-development-goals-kick-off-with-start-of-new-year/

APPENDIX 2: Climate related risks

Type	Climate-Related Risks	Potential Financial Impact
Transition (Carbon)	**Policy and Legal**	
	► Increased pricing of GHG emissions	► Increased operating costs
	► Enhanced emissions-reporting obligations	► Write-offs and asset impairment
	► Regulation of existing products and services	► Increased cost & reduced demand for products/services
	► Exposure to litigation	► Fines and Judgments
	Technology	
	► Substitution of existing products and services with lower emissions options	► Reduced demand for products and services
	► Unsuccessful investment in new technologies	► Increased production costs due to changing input prices (e.g. energy) and output requirements (e.g. waste treatment)
	► Costs to transition to lower emissions tech	► Abrupt unexpected shifts in energy costs
		► Decreased revenues
		► Re-pricing of assets (e.g. fossil-fuel reserves, land valuations, securities valuations)
	Reputation	
	► Shifts in customer preferences	► Reduced revenue from decreased demand
	► Stigmatization of sector	► Reduced revenue from decreased production capacity (e.g. delayed planning approvals, supply chain interruptions)
	► Increased stakeholder concern or negative stakeholder feedback	► Reduced revenue from negative impact on workforce management and planning (e.g. employee attraction and retention)
		► Reduction in capital availability
Physical	**Acute**	
	► Increased severity of extreme weather events such as hurricanes, drought, and floods	► Reduced revenue from decreased production capacity (e.g. transport difficulties, supply chain interruptions)
	Chronic	► Reduced revenue and higher costs from negative impacts on workforce (e.g. health, safety, absenteeism)
	► Changes in precipitation patterns and extreme variability in weather patterns	► Write-offs and early retirement of existing assets (e.g. damage to property and assets in high-risk locations)
	► Rising mean temperatures	► Increased operating costs (e.g. inadequate water supply for hydroelectric plants or to cool nuclear and fossil-fuel plants)
	► Rising sea levels	► Increased capital costs (e.g. damage to facilities)
		► Reduced revenues from lower sales/output
		► Increased insurance premiums and potential for reduced availability of insurance on assets in high-risk locations

Source: TCFD, Final Report, Recommendations of the Task Force on Climate-Related Financial Disclosures, P.10, https://www.fsb.tcfd.org/wp-content/uploads/2017/06/FINAL-TCFD-Report-062817.pdf

APPENDIX 3: RobecoSAM's assessment methodology[22]



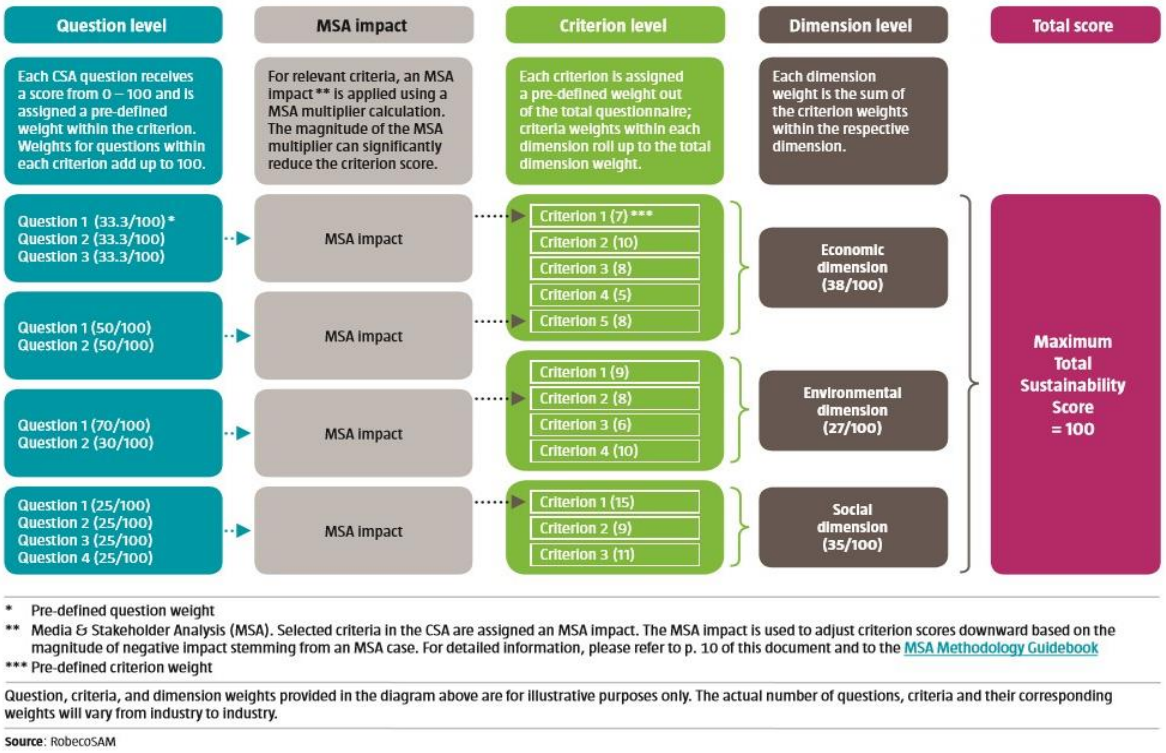
[22] https://www.sustainability-indices.com/index-family-overview/djsi-index-family.html

APPENDIX 4: Type of scoring at RobecoSAM[23]

Scoring Type	Description	Sample Questions
Transparency	Public disclosure	• Human Rights Disclosure
	Availability of qualitative or quantitative information	• Largest Contributions and Expenditures
Performance	Scoring of qualitative or quantitative data based on pre-defined thresholds or expectations.	• Board Structure • Human Rights Assessment
	Trend scoring on company's own performance over time	• Operational Eco-Efficiency
	Linear peer group scoring	• Lost Time Injury Frequency Rate • Employee Turnover Rate

Source: RobecoSAM

APPENDIX 5: Overview of RobecoSAM scoring methodology[24]



* Pre-defined question weight

** Media & Stakeholder Analysis (MSA). Selected criteria in the CSA are assigned an MSA impact. The MSA impact is used to adjust criterion scores downward based on the magnitude of negative impact stemming from an MSA case. For detailed information, please refer to p. 10 of this document and to the MSA Methodology Guidebook

*** Pre-defined criterion weight

Question, criteria, and dimension weights provided in the diagram above are for illustrative purposes only. The actual number of questions, criteria and their corresponding weights will vary from industry to industry.

Source: RobecoSAM

[23] https://www.robecosam.com/media/3/8/f/38fe11a7622afc00181ef19f865c2972_csa-2018-annual-scoring-methodology-review_tcm1016-14369.pdf

[24] https://assessments.robecosam.com/documents/measuring_intangibles_csa-methodology.pdf

APPENDIX 6 : MSCI ACWI Index market allocation[25]

[25] https://www.msci.com/acwi

APPENDIX 7: Theoretical analysis explanation

3.3. Statistical tests

The different tests will be explained in this section before reviewing the models used in this thesis. Those tests will allow us to analyze the statistic distribution of the indices' returns, their autocorrelation and finally, the correlation between different indices.

3.3.1. Normal distribution

The first test to perform is the Jarque–Bera test. It is used in statistics to verify whether a sample data has the skewness and kurtosis matching a normal distribution. In our analysis, the skewness relates to the asymmetry of the returns while the kurtosis refers to extreme events. A normal distribution shows a skewness of zero and a kurtosis of 3. This test statistic is always nonnegative. If the result is far from zero, we can conclude that the data do not have a normal distribution.

3.3.2. Autocorrelation

The analysis of autocorrelation allows to find repeating patterns. It can be a signal for periodic trend obscured by noise for example. It represents the degree of similarity between a time series and a lagged version of itself over successive time intervals. Thus, autocorrelation highlights the relationship between a variable's current value and its past values. In the case of a positive autocorrelation with a value of 1, we can conclude that the series are perfectly and positively correlated, while a negative autocorrelation with a value of -1, shows that the series are perfectly and negatively correlated. Finally, an autocorrelation value near zero can be seen as no correlation. In finance, analysts use autocorrelation to measure the impact of past prices have on future prices for a security (Smith, 2019).

3.3.3. Correlation

In statistics, the correlation represents a statistical relationship, whether causal or not, between two random variables or bivariate data. It shows the degree of linear relationship between two variables and indicates if this relationship can be used in practice. In our analysis it will allow us to determine if a link exists between the performance of our low carbon indices and the performance of the traditional ones.

Moreover, it will indicate the level of this possible relationship. A high correlation value, whether it's positive or negative, means that the performance of the indice can mostly be explained by the performance of the indice it is correlated to, while a low value means that there is no link between the performances of the two indices.

3.4. Performance

In order to assess the performance of the low carbon indices and the traditional ones, we will use different types of indicator. Two models will be used, the CAPM and its extension: the FAMA-FRENCH model. Then we will take a look at several ratios namely: the Sharpe ratio, the Treynor ratio, the Sortino ratio and the Information ratio.

3.4.1. The CAPM

The Capital Asset Pricing Model is used to describe the relationship between the market risk and expected return of an asset. It allows to put a price on a security matching with the expected returns. It takes the form of the following formula:

$$ER_i - R_f = \alpha_i + \beta_i * (ER_m - R_f)$$

Where:

ER_i is the expected return of investment

R_f is the Risk-free rate

β_i is the Beta of the investment

ER_m is the expected return of market

$(ER_m - R_f)$ is the Market risk premium

Thanks to this model we can introduce the Jensens' Alpha which represents the difference between the actual return of an asset and the one predicted by the CAPM. It, therefore, indicates the risk-adjusted performance of the asset. The Jensens' Alpha, or simply Alpha, is calculated as follow:

$$Alpha = R_i - (R_f + \beta_i * (R_m - R_f))$$

In our analysis, the Alpha will show how our low carbon indices perform in comparison of the traditional ones.

The Beta (β_i), on the other hand, measures the volatility, of a specific security in comparison to the unsystematic risk of the market. In order to capture this difference, the beta is calculated thanks to the covariance between the asset's return and the market's return, as stated below:

$$\beta i = \frac{Covariance\ (R_i, R_m)}{Variance\ (R_m)}$$

This Beta will let us know if the low carbon indices follow the market trend or not.

Additionally, we will use the R^2 to assess the proportion in which the model is adapted to explain the results. A bigger R^2 means a better model. The R^2 of the CAPM and the FAMA-FRENCH that we will perform will show the percentage of returns that can be explained by the indices of reference.

3.4.2. The FAMA-FRENCH model

The FAMA-FRENCH model is an extension of the CAPM. It was developed in order to take more factors into account while trying to price a security. The two additional factors relate to the size and the value of the companies. Indeed, studies (Hayes, 2019) have shown that small cap stocks are risker but also generate higher returns. The formula developed by Eugene Fama and Kenneth French is described here below:

$R_{it} - R_{ft} = \alpha_i + \beta_1 * (R_{mt} - R_{ft}) + \beta_2 * SMB_t + \beta_3 * HML_t + \varepsilon_{it}, \quad with\ t = 1, 2, ..., T$

Where:

R_{it} is the total return of a stock or portfolio, i at time t;

R_{ft} is the risk-free rate of return at time t;

R_{mt} is the total market portfolio return at time t;

$R_{it} - R_{ft}$ is expected excess return;

$R_{mt} - R_{ft}$ is the excess return on the market portfolio (index);

SMB_t is the size premium (small minus big);

HML_t is the value premium (high minus low);

β1,2,3 refer to the factor coefficients.

SMB accounts for publicly traded companies with small market caps that generate higher returns, while HML accounts for value stocks with high book-to-market ratios that generate higher returns in comparison to the market. Including these two factors will create a better model as it will adjust to outperformance trends.

3.4.3. The ratios

Several ratios can also help us evaluate the performance of our indices.

a) The Sharpe ratio

The first one is the Sharpe ratio. It is used to understand the return of an investment compared to its risk. The ratio is the average return earned in excess of the risk-free rate per unit of volatility or total risk and the formula is described here below:

$$Sharpe\ Ratio = \frac{R_p - R_f}{\sigma_p}$$

Where:

R_p is the return of portfolio

R_f is the risk-free rate

σ_p is the standard deviation of the portfolio's excess return

Generally, the greater the value of the Sharpe ratio, the more attractive the risk-adjusted return. A Sharpe ratio above 1 means that the investment outperforms a risk-free investment. If it is between 0 and 1 it means that the surplus of risk taken isn't rewarding enough and under 0, the investment underperforms the risk-free investment and that there is no use in taking that additional risk.

b) The Treynor ratio

The second one is the Treynor ratio. It is based on the same principle as the Sharpe ratio: assessing the excess return generated for each unit of risk taken on by a portfolio. The difference between those two ratios is that Treynor's uses the beta instead of the standard deviation. As a result, the formula only differs on this parameter.

$$Treynor\ Ratio = \frac{R_p - R_f}{\beta_p}$$

Where:

R_p is the return of portfolio

R_f is the risk-free rate

β_p is the beta of the portfolio

The result can be interpreted the same way as the Sharpe ratio.

c) The Sortino ratio

Another interesting expansion of the Sharpe ratio is the Sortino ratio. The difference here is that we differentiate harmful volatility from total overall volatility. In order to do this, we only use the asset's standard deviation of negative portfolio returns (the downside deviation) instead of the total standard deviation of portfolio returns. Thanks to this differentiation, the Sortino ratio helps address the issue caused by using total risk, or standard deviation. Indeed, upside volatility is beneficial to investors and isn't a factor most investors worry about. By focusing on the downside deviation, it gives a better view of a portfolio's risk-adjusted performance since positive volatility is a benefit (Kenton, 2019). The result can be interpreted the same way as the Sharpe ratio and the formula is the following:

$$Sortino\ Ratio = \frac{R_p - R_f}{\sigma_d}$$

Where:

R_p is the return of portfolio

R_f is the risk-free rate

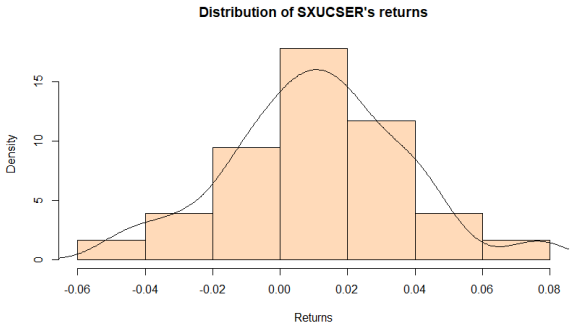
σ_d is the standard deviation of the downside

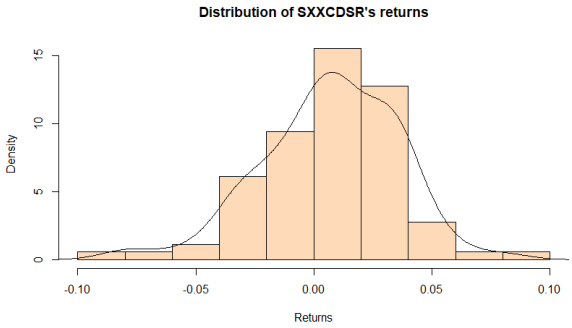
d) The information ratio

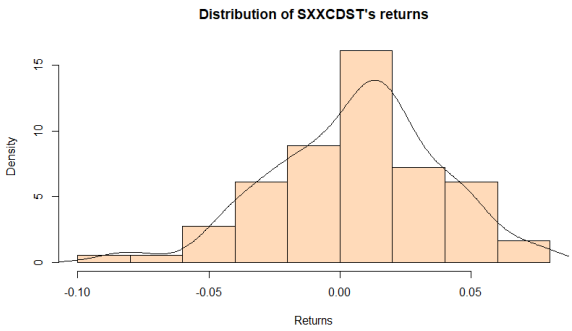
Finally, the information ratio (IR) measures a portfolio returns beyond the returns of a benchmark in comparison with the volatility of those returns. The benchmark is generally an index. This IR allows us to identify the consistency of the performance by incorporating a tracking error, or standard deviation component into the calculation. This tracking error shows whether the portfolio is consistently beating the index over time or not. A higher IR result means that the portfolio manager is achieving a higher return in excess of the benchmark, given the risk taken.

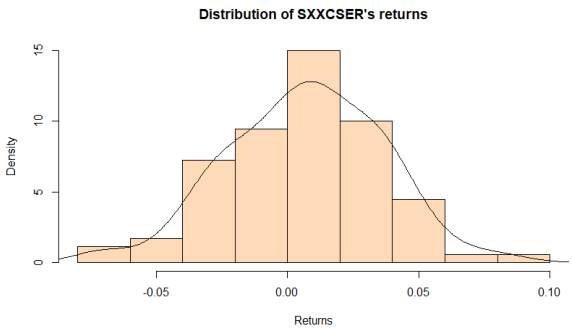
$$Information\ ratio = \frac{Portfolio\ Return - Benchmark\ return}{Tracking\ error}$$

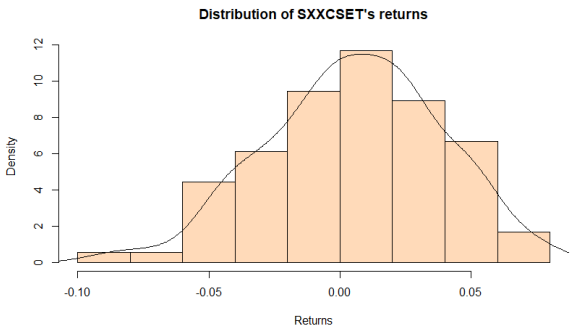
APPENDIX 8: Shape of returns' distribution by index

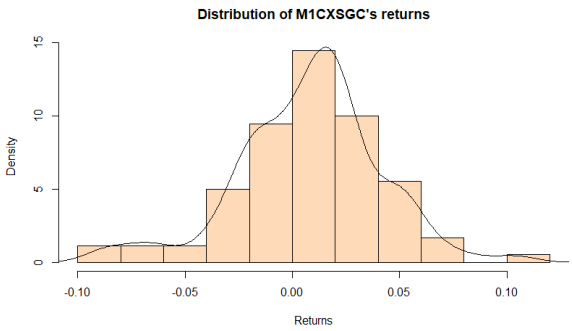


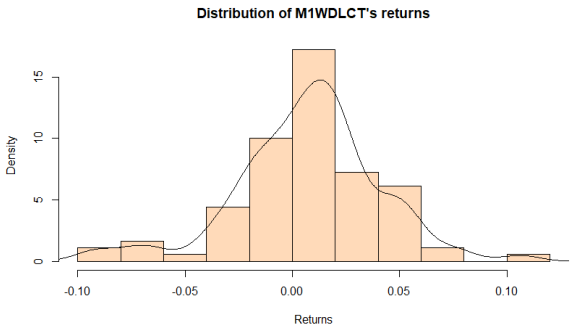


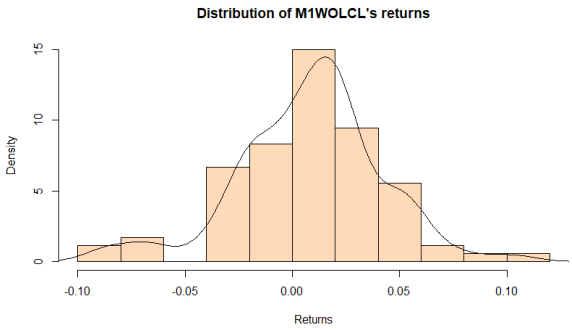


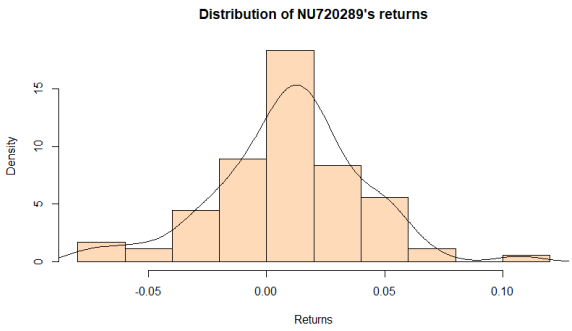


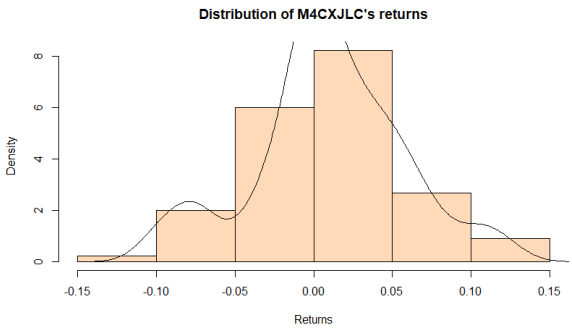


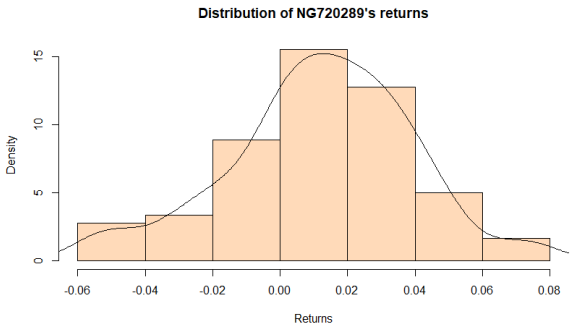


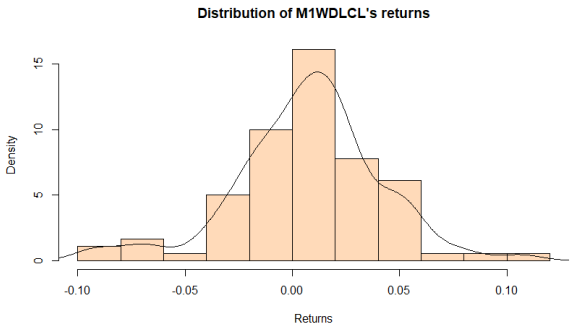


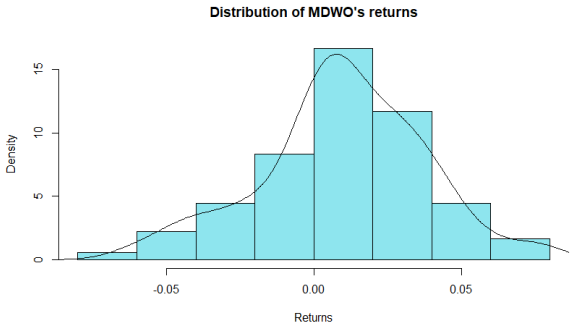


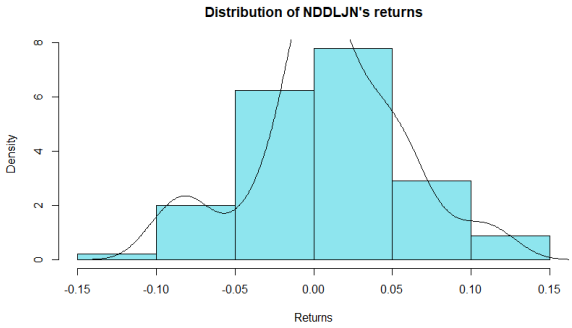


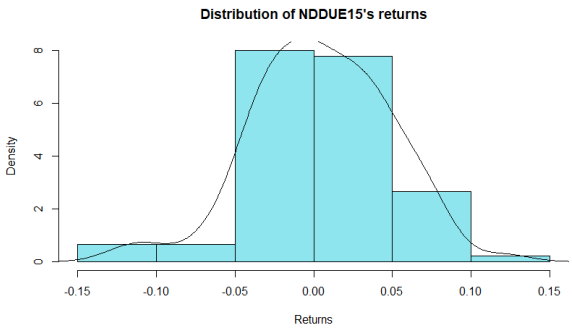


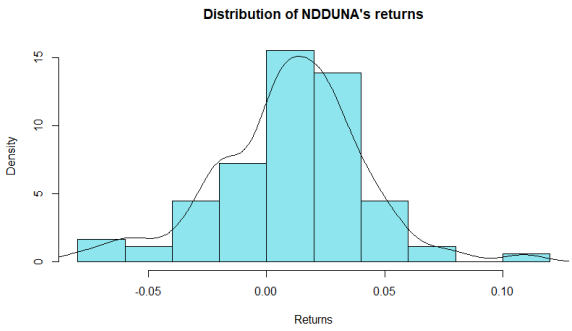

Distribution of NG720289's returns
Density
Returns

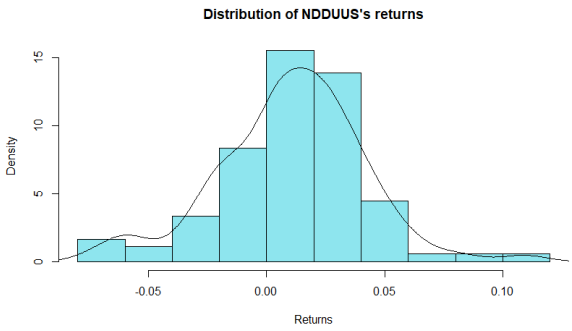

Distribution of M1WDLCL's returns
Density
Returns

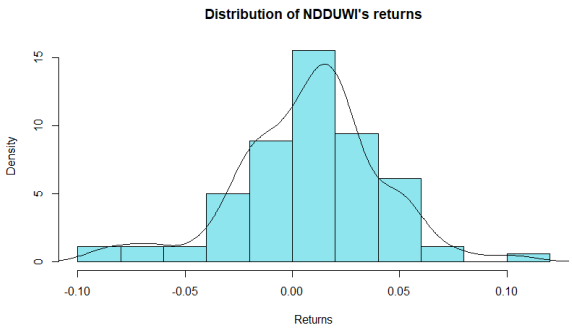

Distribution of MDWO's returns
Density
Returns

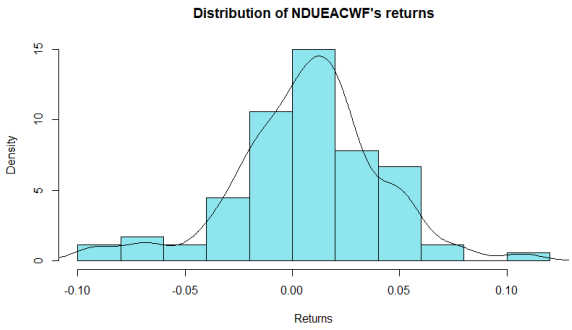

Distribution of NDDLJN's returns
Density
Returns

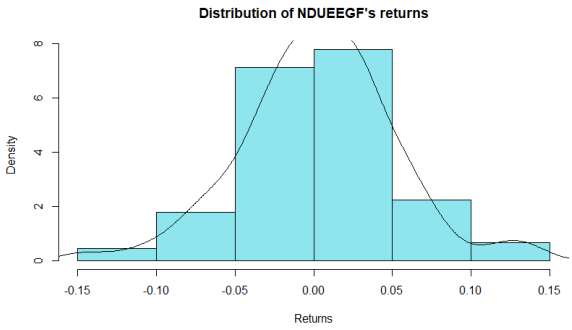

Distribution of NDDUE15's returns
Density
Returns

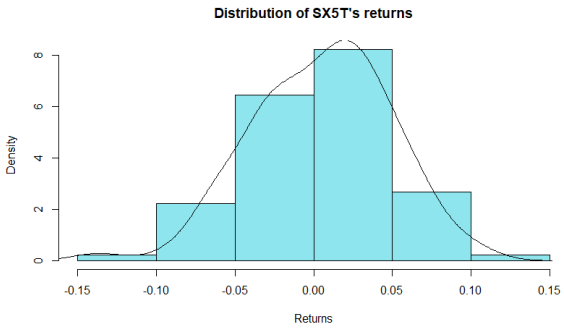

Distribution of NDDUNA's returns
Density
Returns

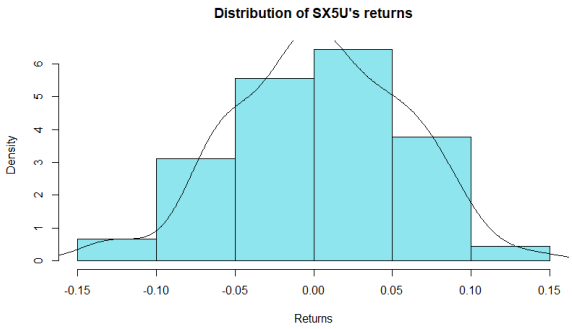

Distribution of NDDUUS's returns
Density
Returns


Distribution of NDDUWI's returns
Density
Returns

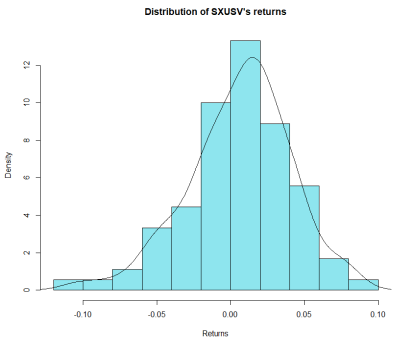

Distribution of NDUEACWF's returns
Density
Returns


Distribution of NDUEEGF's returns
Density
Returns


Distribution of SX5T's returns
Density
Returns
0
2
4
6
8
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15


Distribution of SX5U's returns
Density
Returns
0
1
2
3
4
5
6
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15

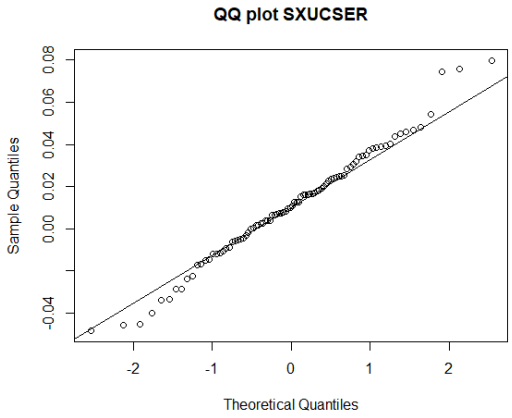

Distribution of SXXR's returns
Density
Returns
0
2
4
6
8
10
12
-0.05
0.00
0.05
0.10

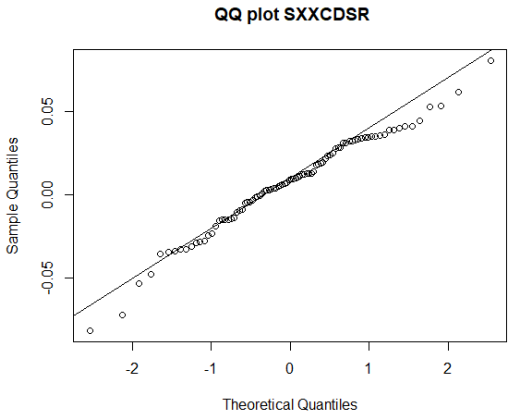

Distribution of SXUSV's returns
Density
Returns
0
2
4
6
8
10
12
-0.10
-0.05
0.00
0.05
0.10

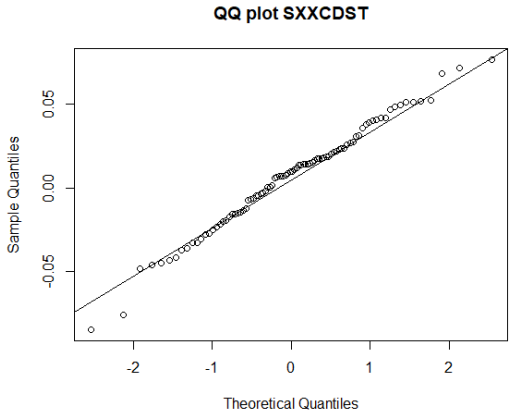
APPENDIX 9: Jarque-Bera tests

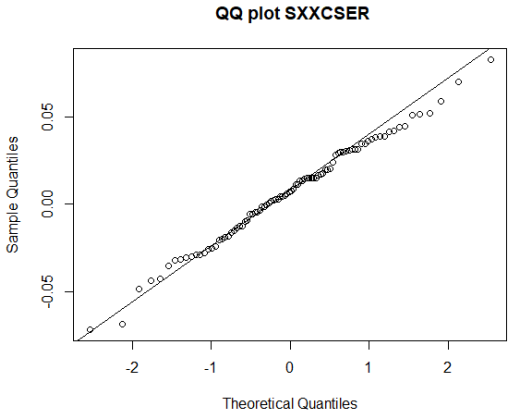
```
        Jarque Bera Test

data:  SXUCSER_returns
X-squared = 0.10042, df = 2, p-value = 0.951

> jarque.bera.test(SXXCDSR_returns)

        Jarque Bera Test

data:  SXXCDSR_returns
X-squared = 5.0364, df = 2, p-value = 0.0806

> jarque.bera.test(SXXCDST_returns)

        Jarque Bera Test

data:  SXXCDST_returns
X-squared = 1.8952, df = 2, p-value = 0.3877

> jarque.bera.test(SXXCSER_returns)

        Jarque Bera Test

data:  SXXCSER_returns
X-squared = 0.70615, df = 2, p-value = 0.7025

> jarque.bera.test(SXXCSET_returns)

        Jarque Bera Test

data:  SXXCSET_returns
X-squared = 1.2675, df = 2, p-value = 0.5306

> jarque.bera.test(M1CXSGC_returns)

        Jarque Bera Test

data:  M1CXSGC_returns
X-squared = 4.835, df = 2, p-value = 0.08914

> jarque.bera.test(M1WDLCT_returns)#maybe not normal

        Jarque Bera Test

data:  M1WDLCT_returns
X-squared = 6.5506, df = 2, p-value = 0.03781

> jarque.bera.test(M1WOLCL_returns)

        Jarque Bera Test

data:  M1WOLCL_returns
X-squared = 4.7453, df = 2, p-value = 0.09323

> jarque.bera.test(NU720289_returns)

        Jarque Bera Test

data:  NU720289_returns
X-squared = 3.6744, df = 2, p-value = 0.1593

> jarque.bera.test(M4CXJLC_returns)

        Jarque Bera Test

data:  M4CXJLC_returns
X-squared = 0.55583, df = 2, p-value = 0.7574

> jarque.bera.test(NG720289_returns)

        Jarque Bera Test

data:  NG720289_returns
X-squared = 1.3544, df = 2, p-value = 0.508

> jarque.bera.test(M1WDLCL_returns)#maybe not normal

        Jarque Bera Test

data:  M1WDLCL_returns
X-squared = 6.3673, df = 2, p-value = 0.04143

data:  TR_NDUEACWF
X-squared = 6.8556, df = 2, p-value = 0.03246

> jarque.bera.test(TR_NDUEEGF)

        Jarque Bera Test

data:  TR_NDUEEGF
X-squared = 2.4831, df = 2, p-value = 0.2889

> jarque.bera.test(TR_SX5T)

        Jarque Bera Test

data:  TR_SX5T
X-squared = 2.1906, df = 2, p-value = 0.3344

> jarque.bera.test(TR_SX5U)

        Jarque Bera Test

data:  TR_SX5U
X-squared = 0.62504, df = 2, p-value = 0.7316

> jarque.bera.test(TR_SXXR)

        Jarque Bera Test

data:  TR_SXXR
X-squared = 4.8043, df = 2, p-value = 0.09053

        Jarque Bera Test

data:  TR_SXUSV
X-squared = 4.0958, df = 2, p-value =
0.129

> jarque.bera.test(TR_MDWO)

        Jarque Bera Test

data:  TR_MDWO
X-squared = 0.53945, df = 2, p-value = 0.7636

> jarque.bera.test(TR_NDDLJN)

        Jarque Bera Test

data:  TR_NDDLJN
X-squared = 0.64542, df = 2, p-value = 0.7242

> jarque.bera.test(TR_NDDUE15)

        Jarque Bera Test

data:  TR_NDDUE15
X-squared = 1.2747, df = 2, p-value = 0.5287

> jarque.bera.test(TR_NDDUNA)

        Jarque Bera Test

data:  TR_NDDUNA
X-squared = 3.8441, df = 2, p-value = 0.1463

> jarque.bera.test(TR_NDDUUS)

        Jarque Bera Test

data:  TR_NDDUUS
X-squared = 2.7629, df = 2, p-value = 0.2512

> jarque.bera.test(TR_NDDUWI)

        Jarque Bera Test

data:  TR_NDDUWI
X-squared = 4.9826, df = 2, p-value = 0.0828
```

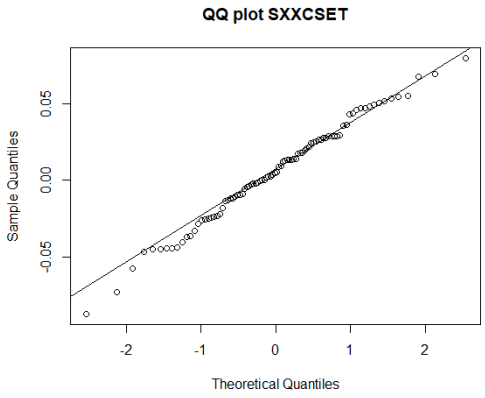
APPENDIX 10: Quantile-quantile graph for each index

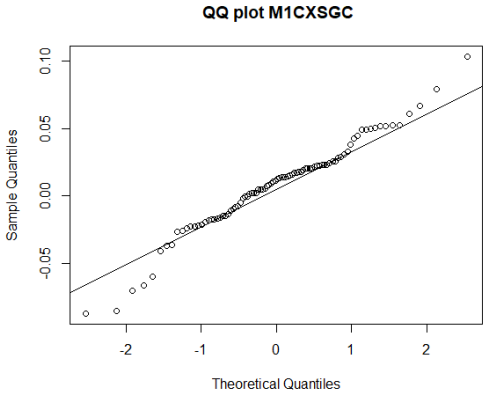


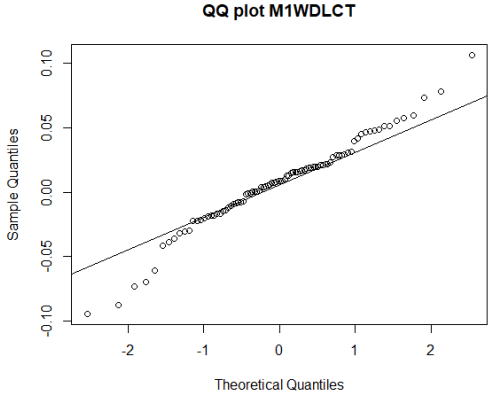


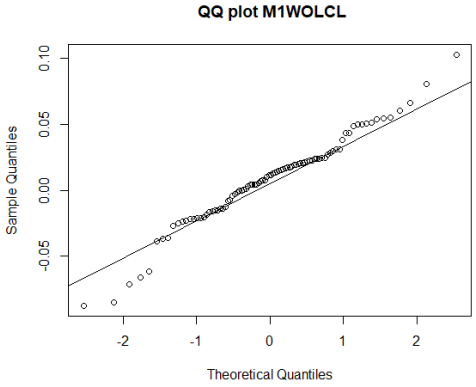


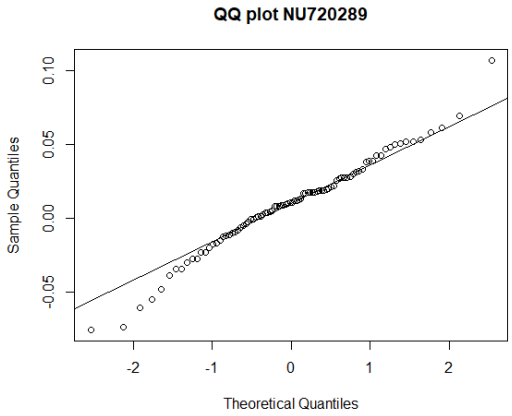


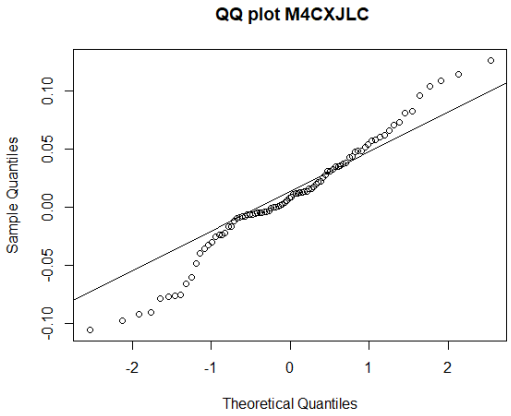


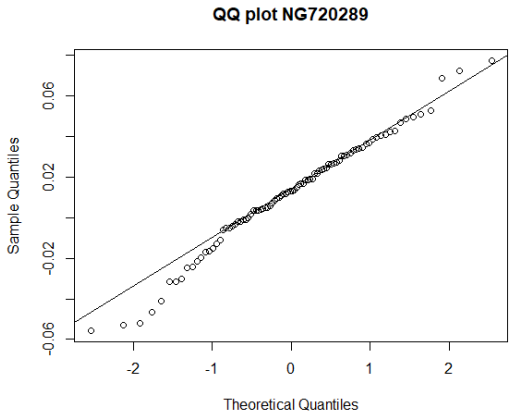


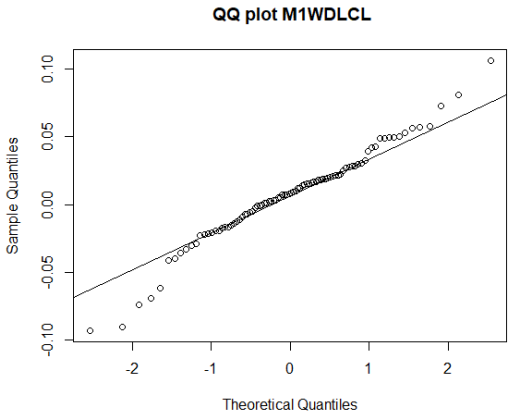


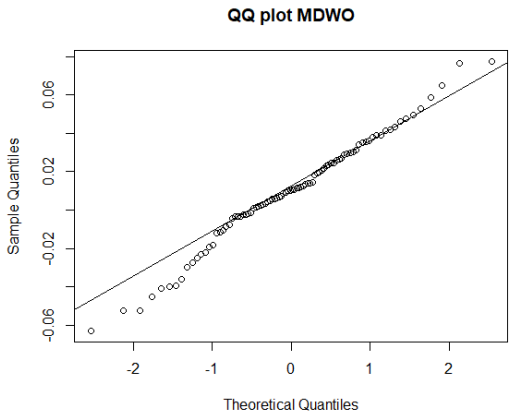


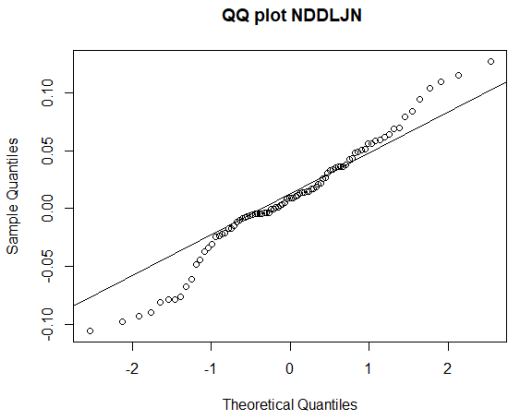

QQ plot NU720289
Sample Quantiles
Theoretical Quantiles
-0.05
0.00
0.05
0.10
-2
-1
0
1
2

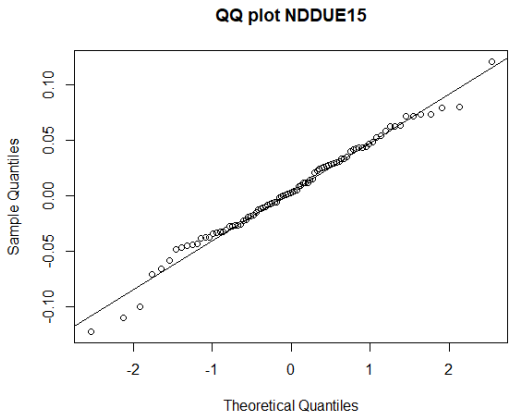

QQ plot M4CXJLC
Sample Quantiles
Theoretical Quantiles
-0.10
-0.05
0.00
0.05
0.10
-2
-1
0
1
2

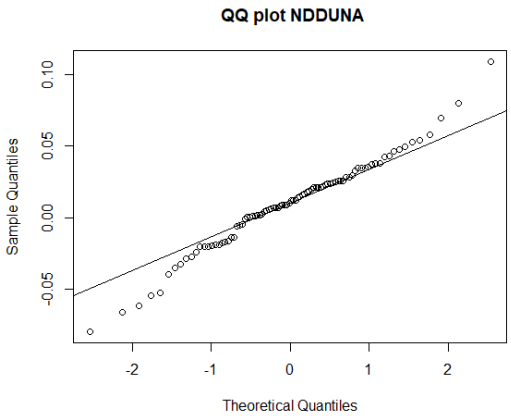

QQ plot NG720289
Sample Quantiles
Theoretical Quantiles
-0.06
-0.02
0.02
0.06
-2
-1
0
1
2

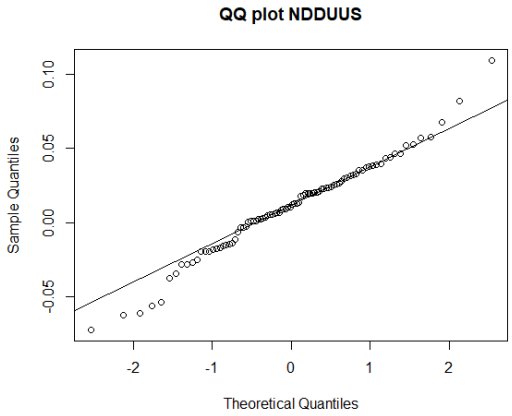

QQ plot M1WDLCL
Sample Quantiles
Theoretical Quantiles
-0.10
-0.05
0.00
0.05
0.10
-2
-1
0
1
2

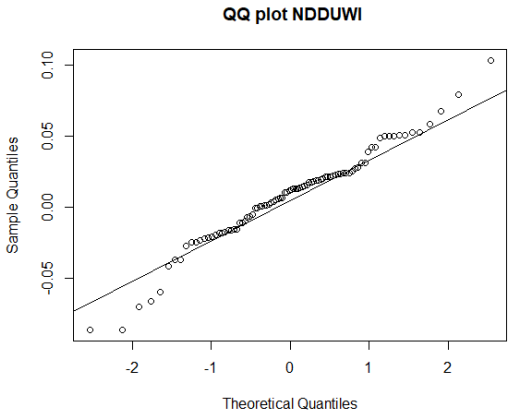

QQ plot MDWO
Sample Quantiles
Theoretical Quantiles
-0.06
-0.02
0.02
0.06
-2
-1
0
1
2

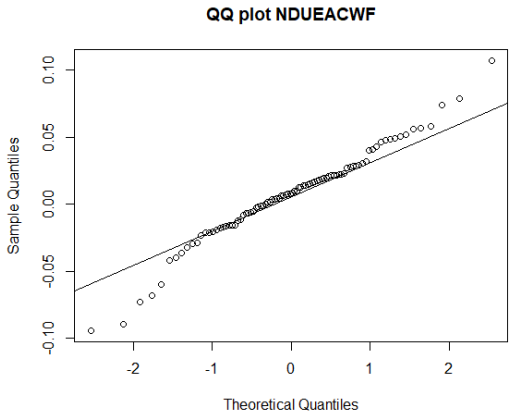

QQ plot NDDLJN
Sample Quantiles
Theoretical Quantiles
-0.10
-0.05
0.00
0.05
0.10
-2
-1
0
1
2

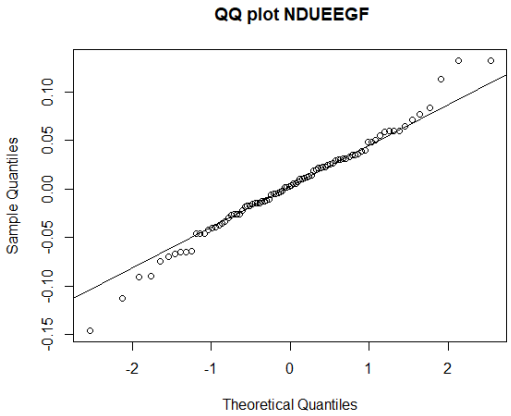

QQ plot NDDUE15
Sample Quantiles
Theoretical Quantiles
-0.10
-0.05
0.00
0.05
0.10
-2
-1
0
1
2

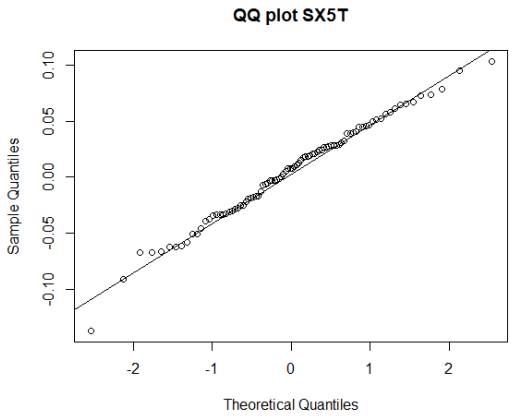

QQ plot NDDUNA
Sample Quantiles
Theoretical Quantiles
-0.05
0.00
0.05
0.10
-2
-1
0
1
2

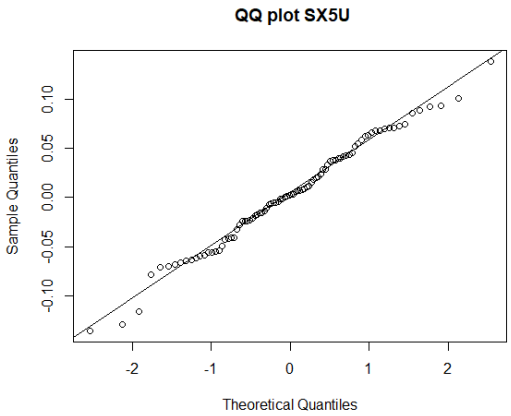

QQ plot NDDUUS
Sample Quantiles
Theoretical Quantiles
-0.05
0.00
0.05
0.10
-2
-1
0
1
2

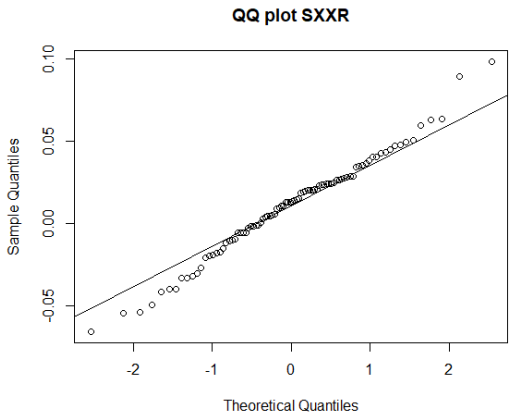

QQ plot NDDUWI
Sample Quantiles
Theoretical Quantiles
-0.05
0.00
0.05
0.10
-2
-1
0
1
2

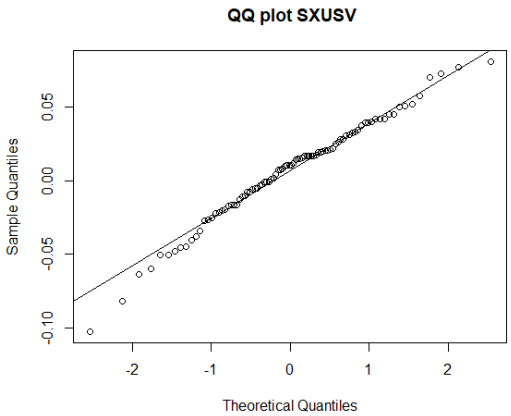

QQ plot NDUEACWF
Sample Quantiles
Theoretical Quantiles
-0.10
-0.05
0.00
0.05
0.10
-2
-1
0
1
2


QQ plot NDUEEGF
Sample Quantiles
Theoretical Quantiles
-0.15
-0.10
-0.05
0.00
0.05
0.10
-2
-1
0
1
2

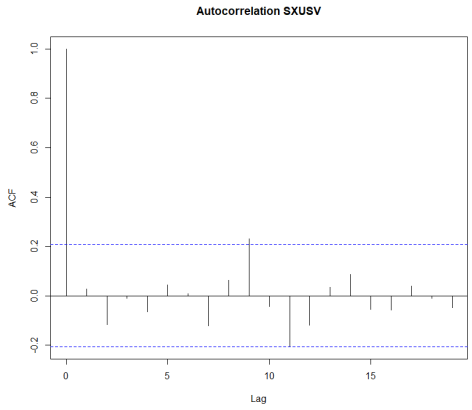

QQ plot SX5T
Sample Quantiles
Theoretical Quantiles
-0.10
-0.05
0.00
0.05
0.10
-2
-1
0
1
2

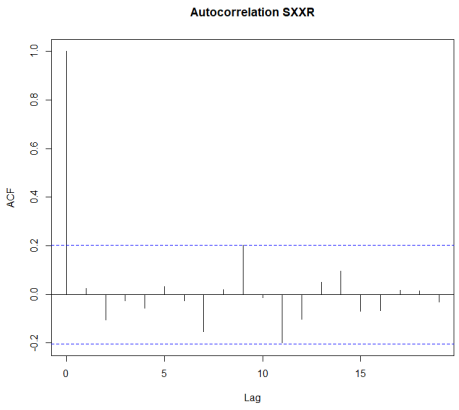

QQ plot SX5U
Sample Quantiles
Theoretical Quantiles
-0.10
-0.05
0.00
0.05
0.10
-2
-1
0
1
2

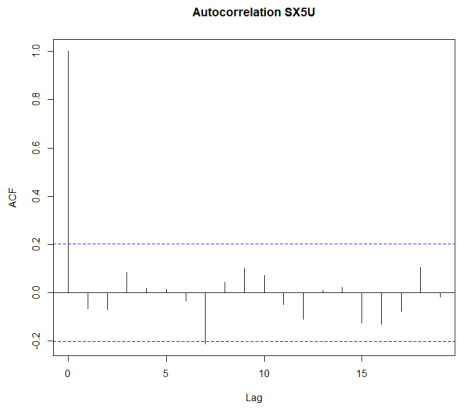

QQ plot SXXR
Sample Quantiles
Theoretical Quantiles
-0.05
0.00
0.05
0.10
-2
-1
0
1
2

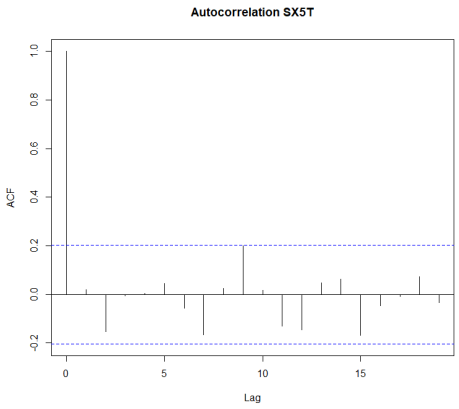

QQ plot SXUSV
Sample Quantiles
Theoretical Quantiles
-0.10
-0.05
0.00
0.05
-2
-1
0
1
2

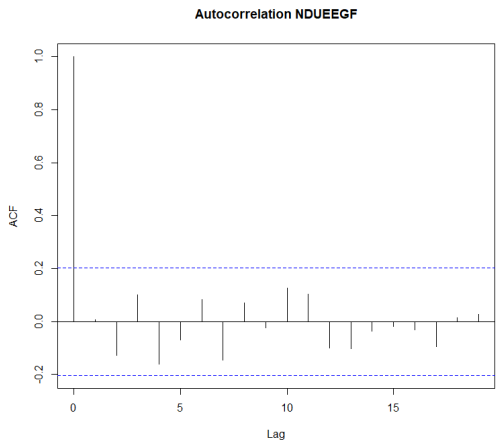
APPENDIX 11: Autocorrelation graphs

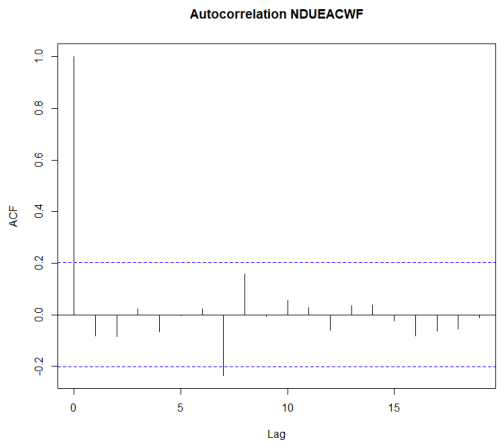


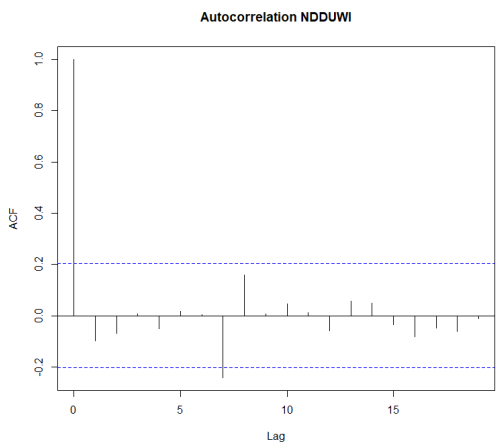


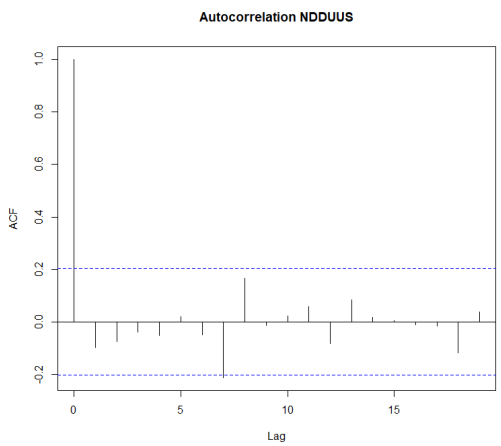




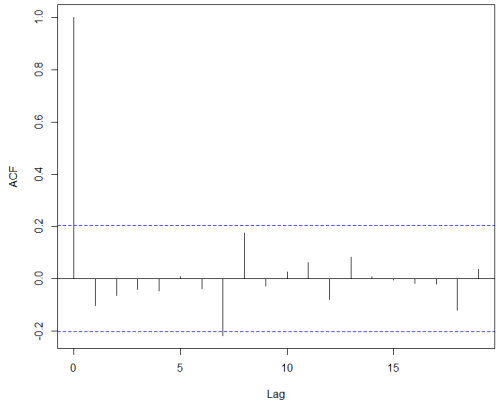




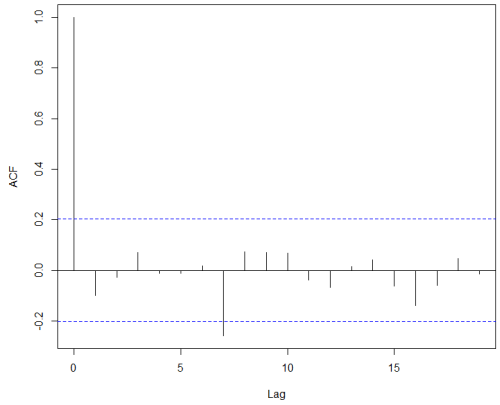




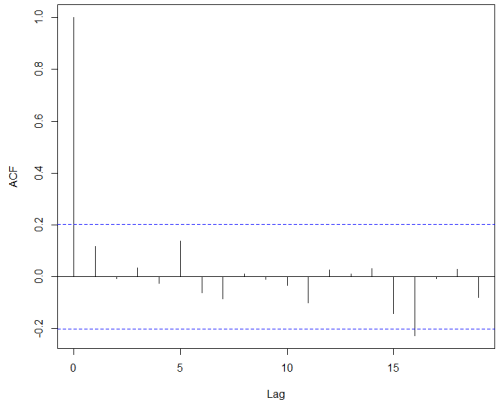
Autocorrelation NDDUNA



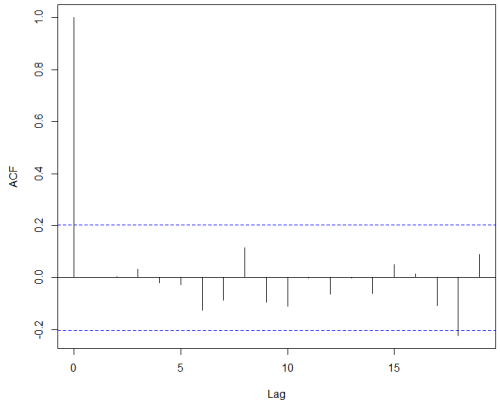
Autocorrelation NDDUE15



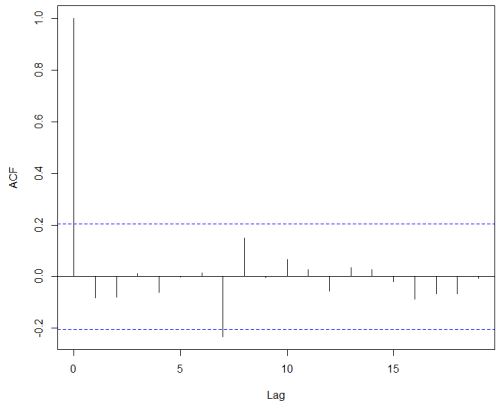
Autocorrelation NDDLJN



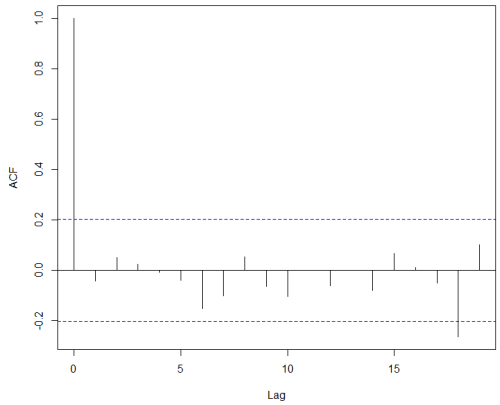
Autocorrelation MDWO



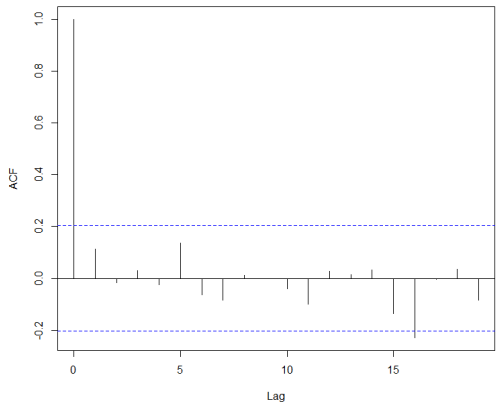
Autocorrelation M1WDLCL



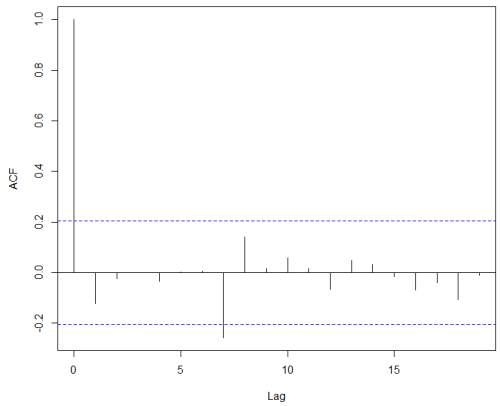
Autocorrelation NG720289

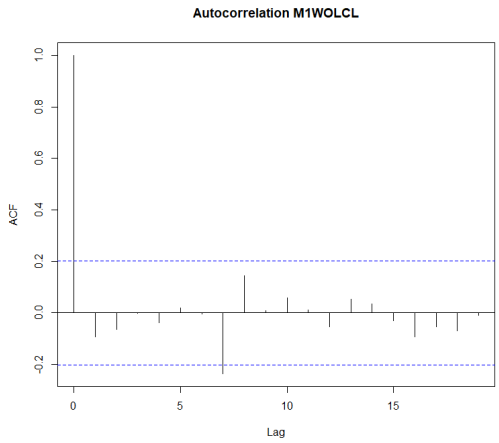


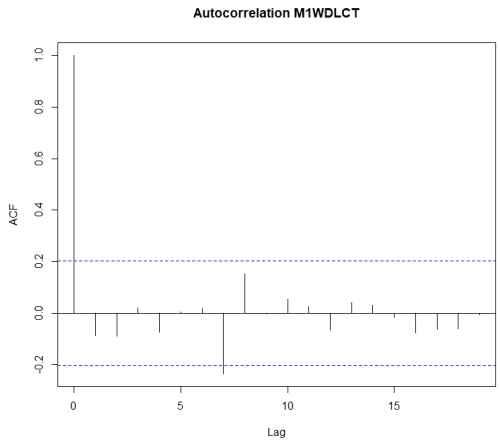
Autocorrelation M4CXJLC

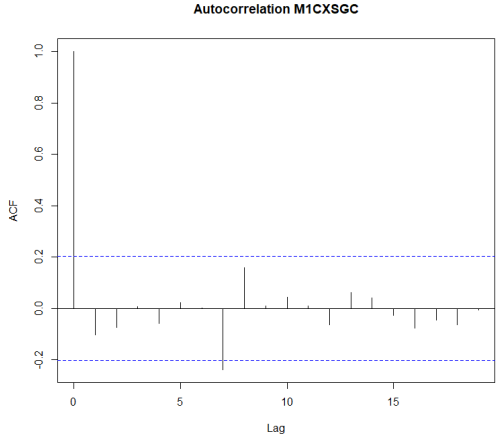


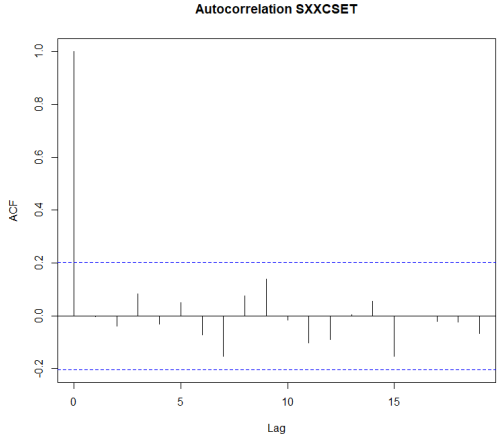
Autocorrelation NU720289

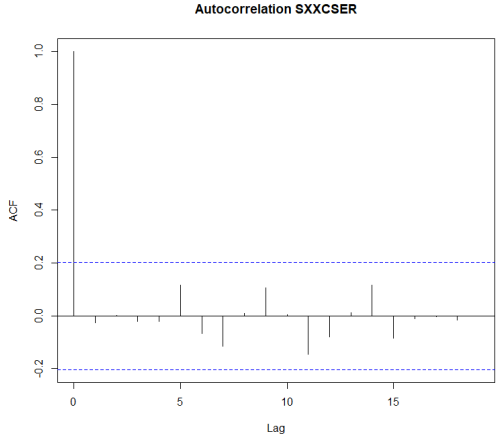


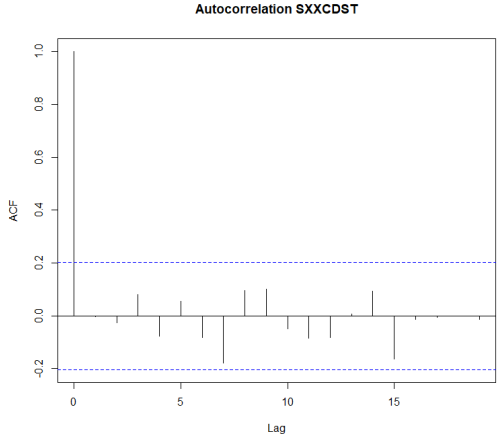

Autocorrelation M1WOLCL
ACF
Lag

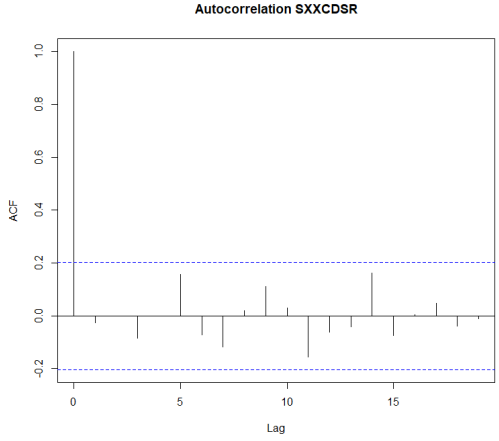

Autocorrelation M1WDLCT
ACF
Lag

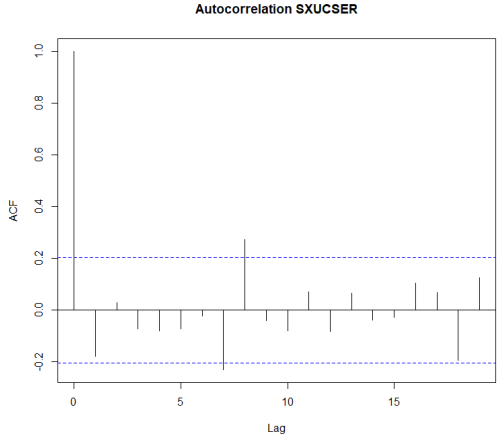

Autocorrelation M1CXSGC
ACF
Lag


Autocorrelation SXXCSET
ACF
Lag


Autocorrelation SXXCSER
ACF
Lag


Autocorrelation SXXCDST
ACF
Lag


Autocorrelation SXXCDSR
ACF
Lag


Autocorrelation SXUCSER
ACF
Lag

APPENDIX 12: T-tests of equality of mean for indices of the same region

WORLD	MDWO	NDDUWI
M1CXSGC	0.7114	0.9819
NG720289	0.6341	0.4948
NU720289	0.9835	0.6911
M1WOLCL	0.7413	0.9537

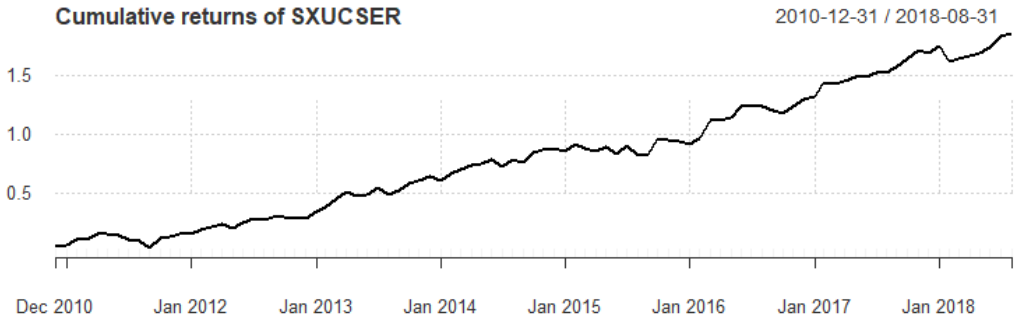
EUROPE	SXXR	NDDUE15	SX5U	SX5T
SXXCDST	0.9761	0.8241	0.776	0.8391
SXXCSET	0.9064	0.9275	0.8652	0.9433
SXXCDSR	0.9233	0.7767	0.7356	0.7916
SXXCSER	0.9187	0.774	0.7332	0.7887

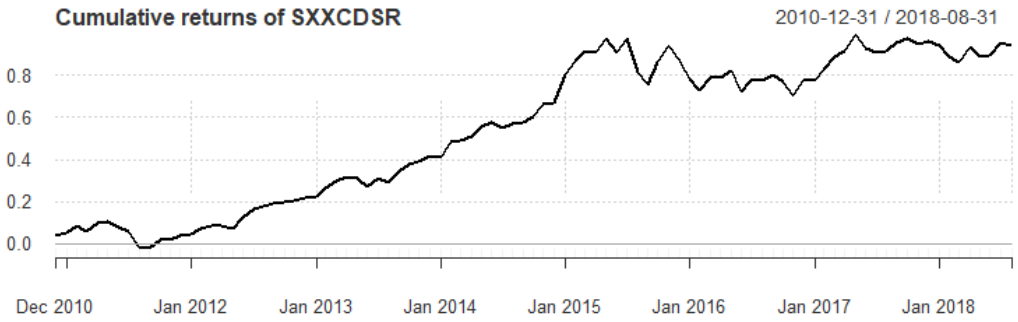
US (+CANADA)	NDDUUS	SXUSV	NDDNA
SXUCSER	0.9509	0.3156	0.8298

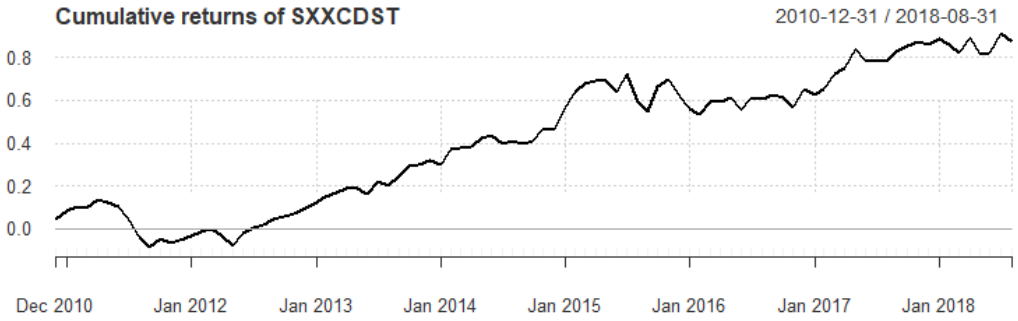
ACWI	NDUEACWF
M1WDLCL	0.9737
NDUEACWF	0.9868

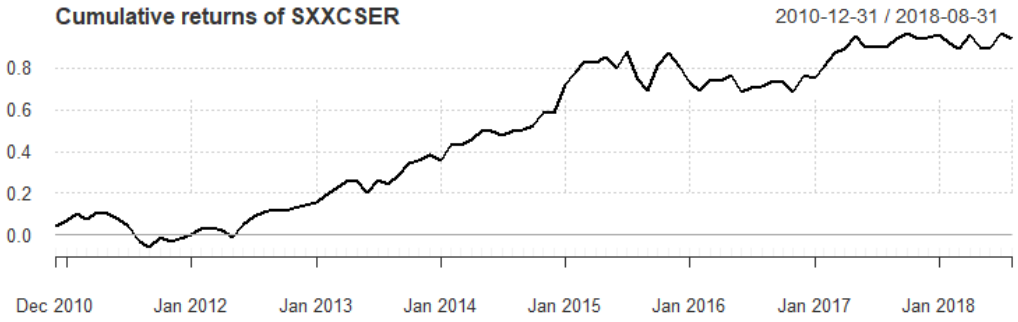
JAPAN	M4CXJLC
NDDLJN	0.9541

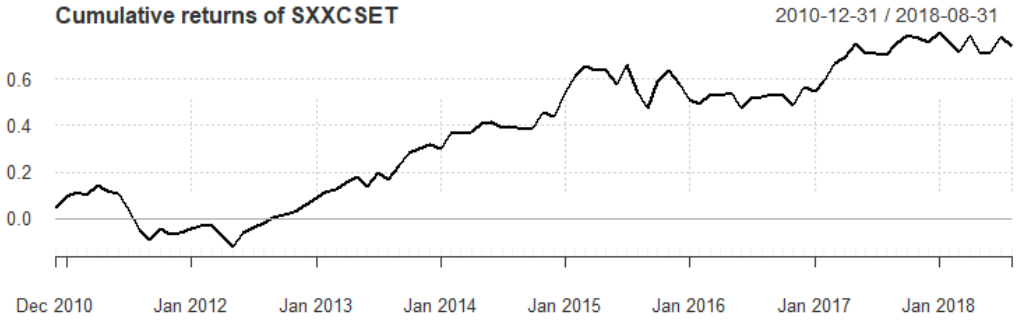
APPENDIX 13: Cumulative returns graph for each index

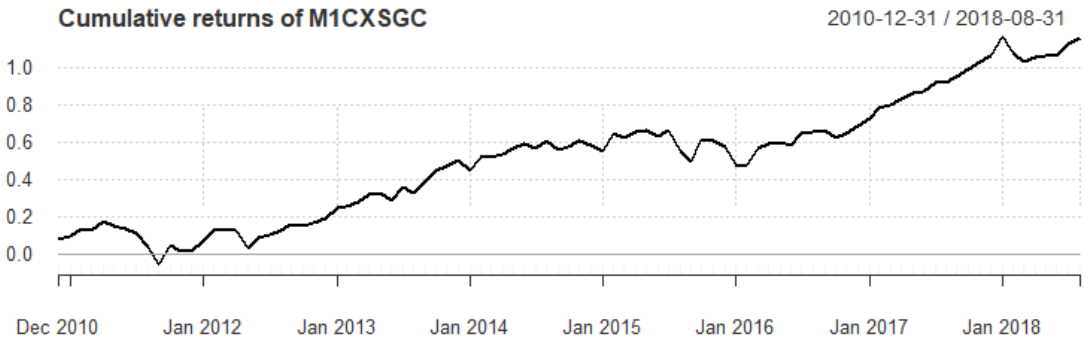


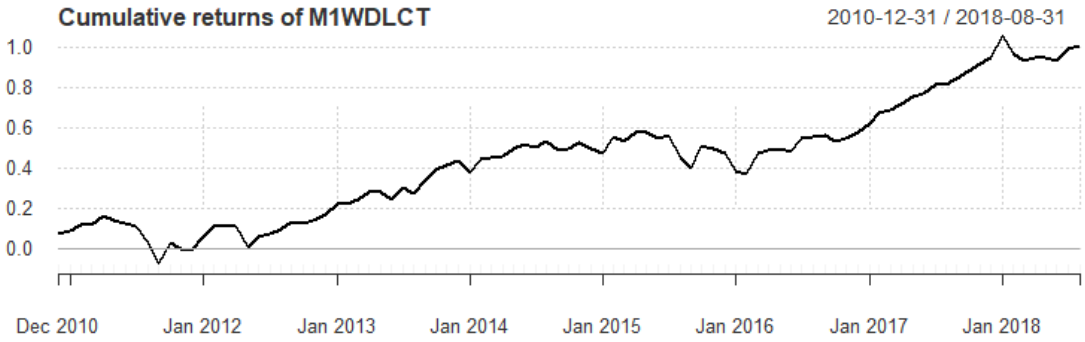


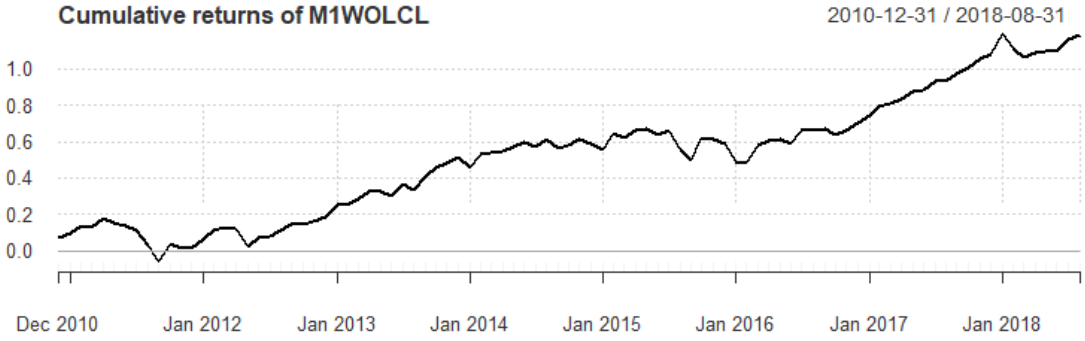


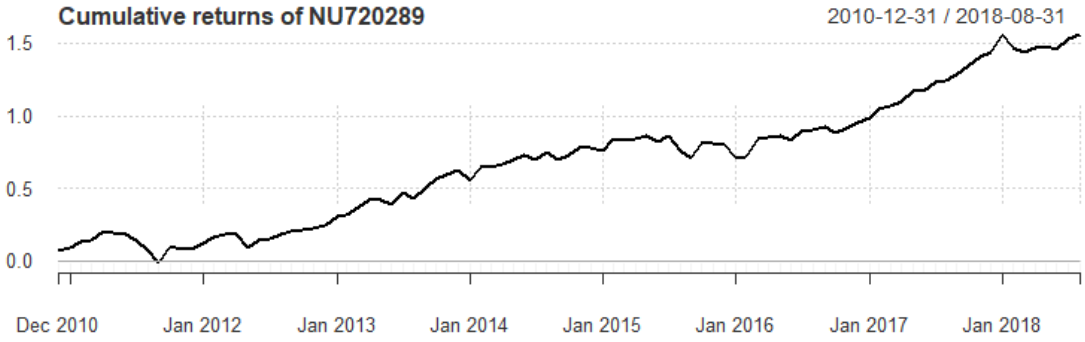


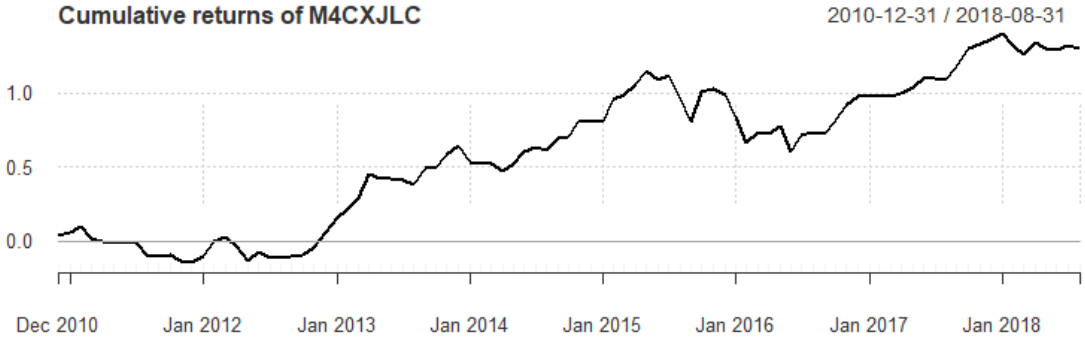


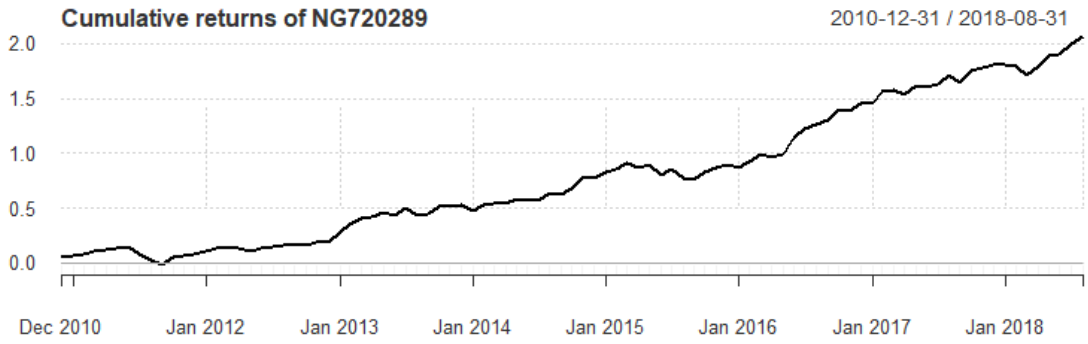

Cumulative returns of M1CXSGC
2010-12-31 / 2018-08-31
1.0
0.8
0.6
0.4
0.2
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018

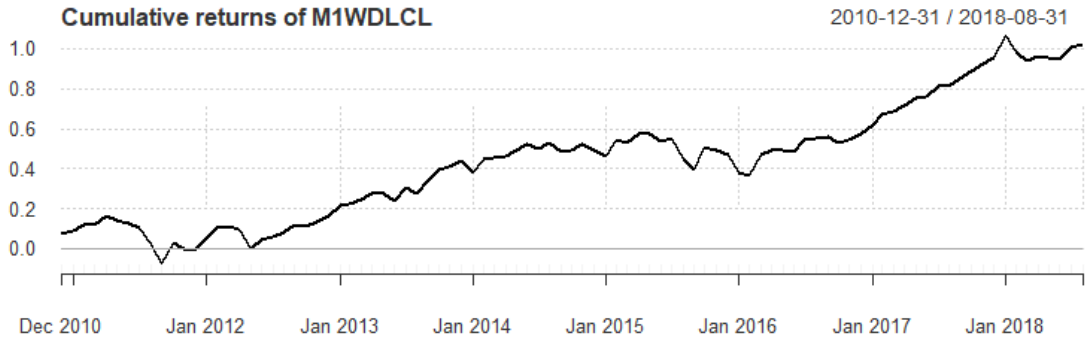

Cumulative returns of M1WDLCT
2010-12-31 / 2018-08-31
1.0
0.8
0.6
0.4
0.2
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018

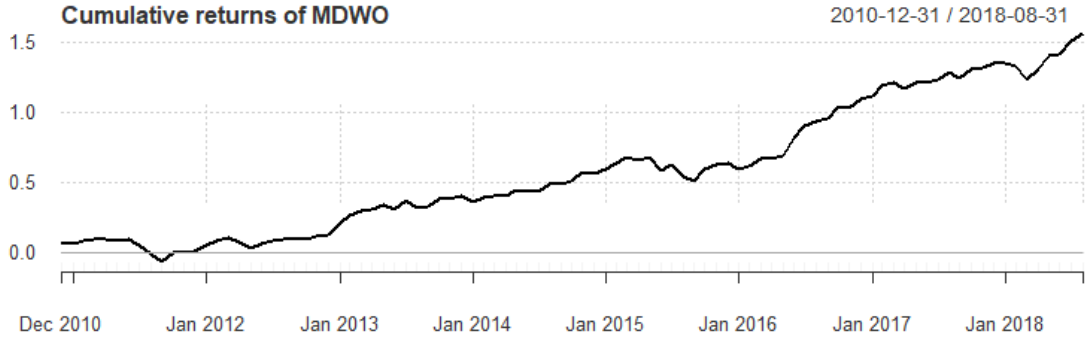

Cumulative returns of M1WOLCL
2010-12-31 / 2018-08-31
1.0
0.8
0.6
0.4
0.2
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018

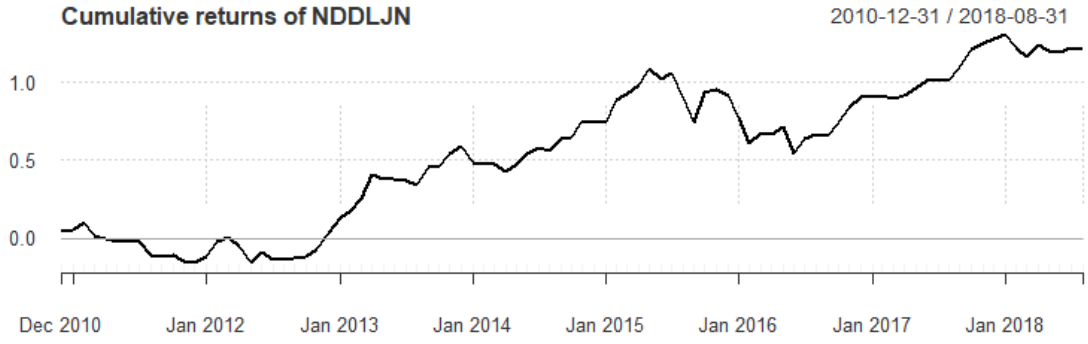

Cumulative returns of NU720289
2010-12-31 / 2018-08-31
1.5
1.0
0.5
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018

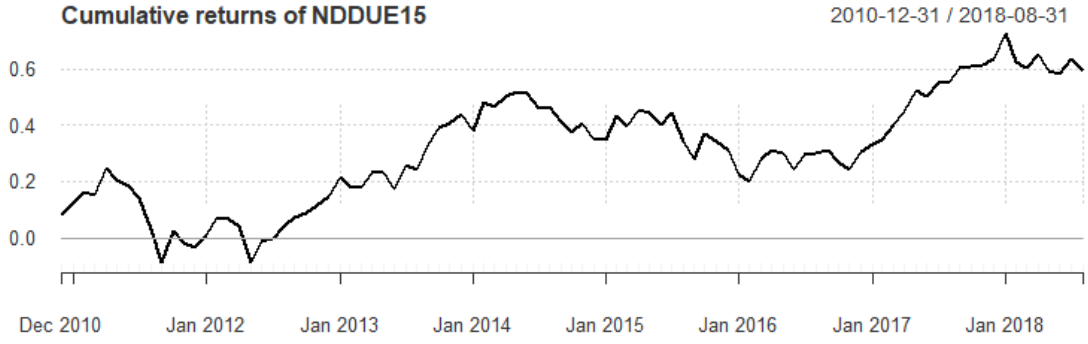

Cumulative returns of M4CXJLC
2010-12-31 / 2018-08-31
1.0
0.5
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018

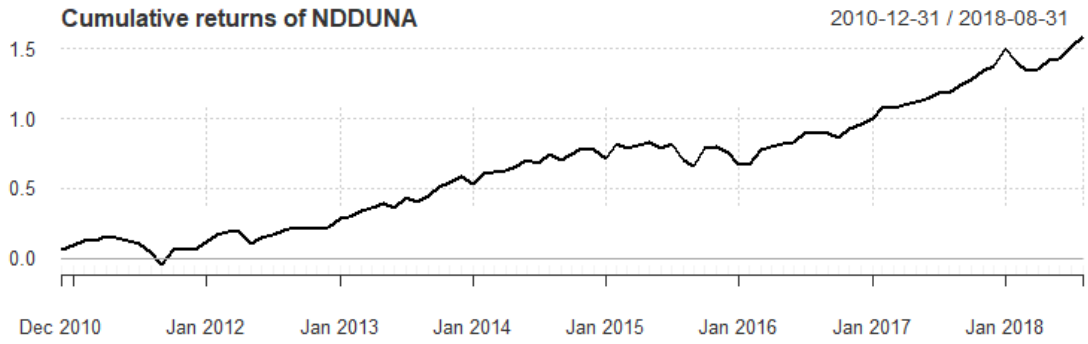

Cumulative returns of NG720289
2010-12-31 / 2018-08-31
2.0
1.5
1.0
0.5
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018

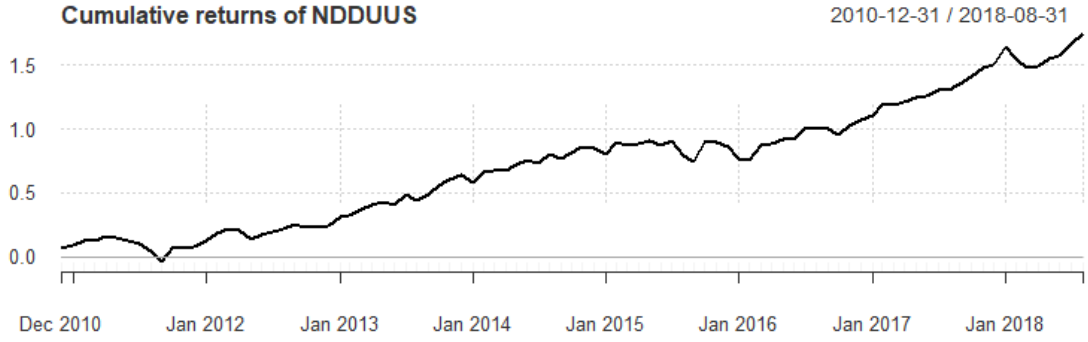

Cumulative returns of M1WDLCL
2010-12-31 / 2018-08-31
1.0
0.8
0.6
0.4
0.2
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018

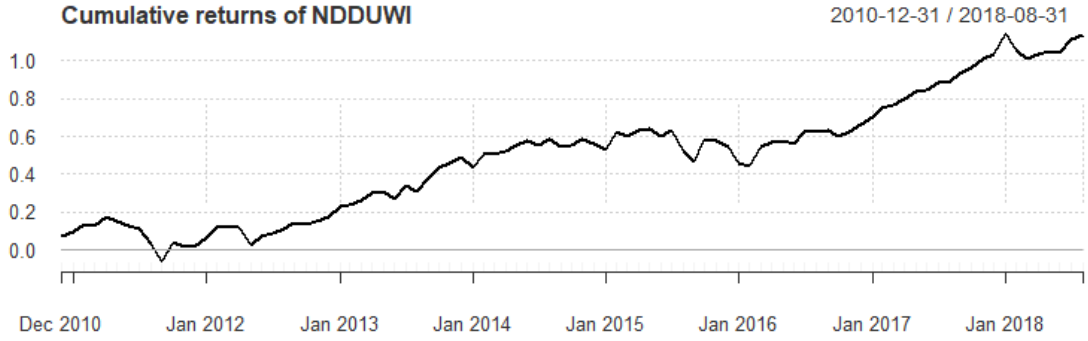

Cumulative returns of MDWO
2010-12-31 / 2018-08-31
1.5
1.0
0.5
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018

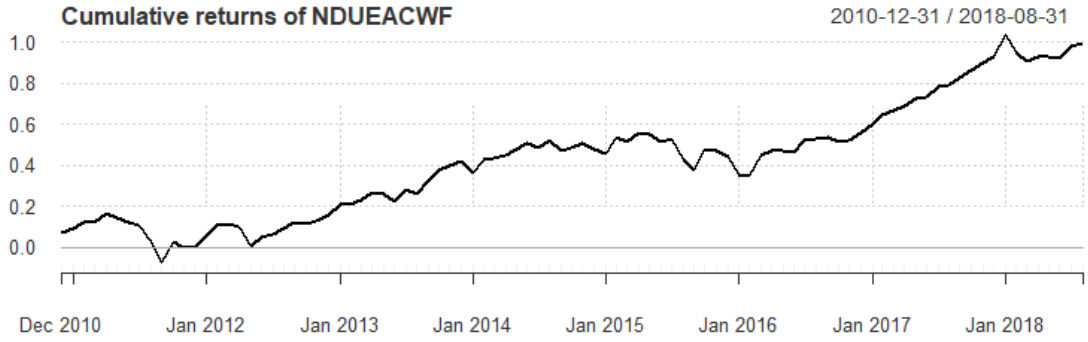

Cumulative returns of NDDLJN
2010-12-31 / 2018-08-31
1.0
0.5
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018

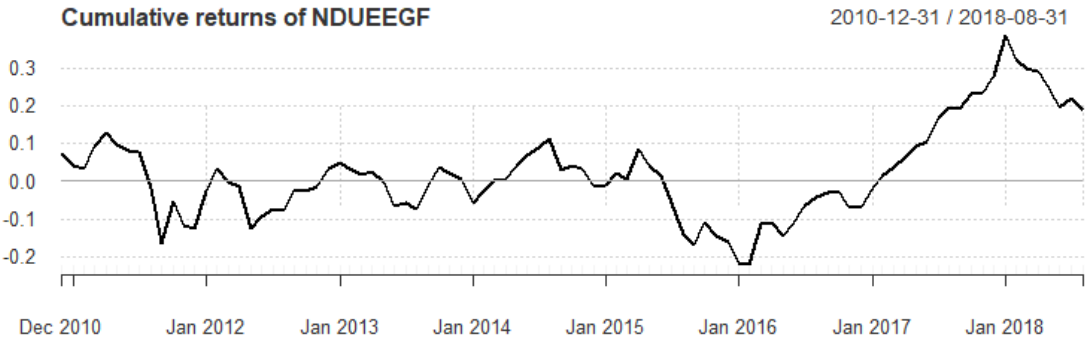

Cumulative returns of NDDUE15
2010-12-31 / 2018-08-31
0.6
0.4
0.2
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018

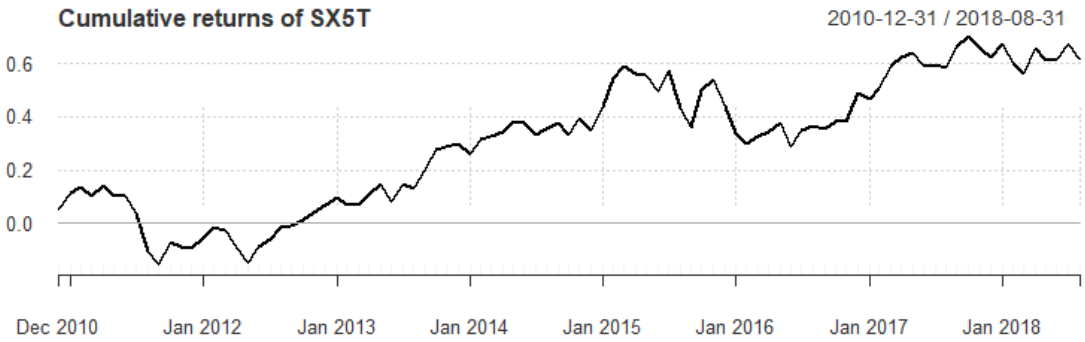

Cumulative returns of NDDUNA
2010-12-31 / 2018-08-31
1.5
1.0
0.5
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018

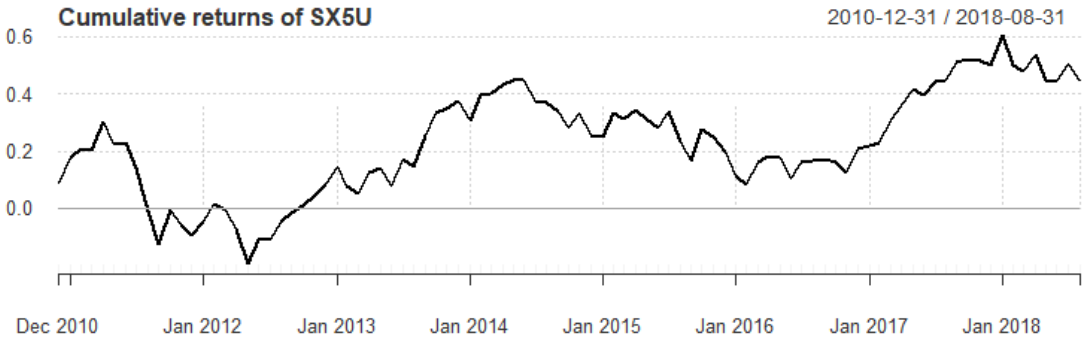

Cumulative returns of NDDUUS
2010-12-31 / 2018-08-31
1.5
1.0
0.5
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018

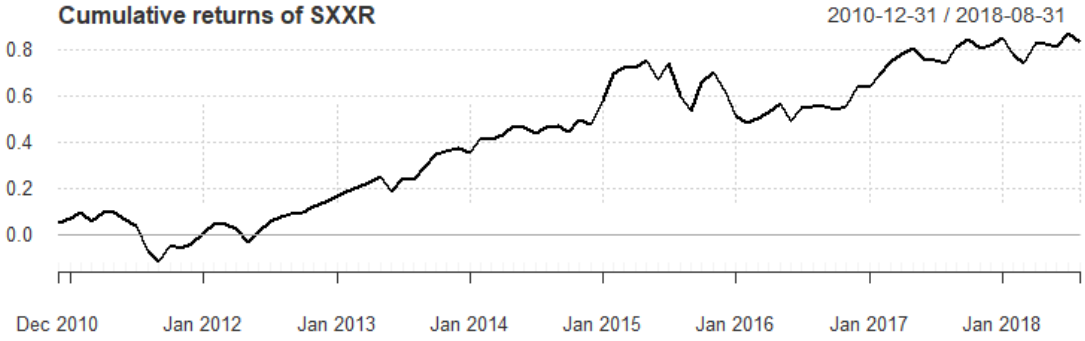

Cumulative returns of NDDUWI
2010-12-31 / 2018-08-31
1.0
0.8
0.6
0.4
0.2
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018

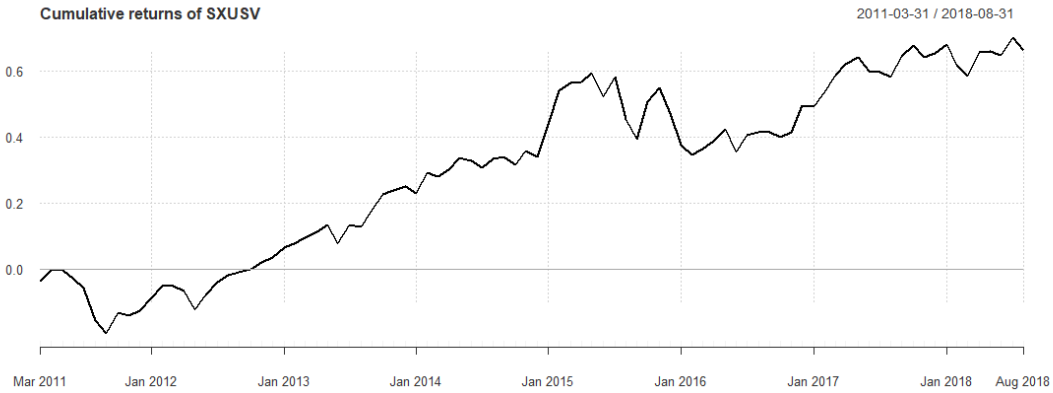

Cumulative returns of NDUEACWF
2010-12-31 / 2018-08-31
1.0
0.8
0.6
0.4
0.2
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018


Cumulative returns of NDUEEGF
2010-12-31 / 2018-08-31
0.3
0.2
0.1
0.0
-0.1
-0.2
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018


Cumulative returns of SX5T
2010-12-31 / 2018-08-31
0.6
0.4
0.2
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018


Cumulative returns of SX5U
2010-12-31 / 2018-08-31
0.6
0.4
0.2
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018


Cumulative returns of SXXR
2010-12-31 / 2018-08-31
0.8
0.6
0.4
0.2
0.0
Dec 2010
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018


Cumulative returns of SXUSV
2011-03-31 / 2018-08-31
0.6
0.4
0.2
0.0
Mar 2011
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018
Aug 2018

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