INSTITUTO UNIVERSITÁRIO DE LISBOA

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Mestrado em Estudos Sociais do Ambiente e Sustentabilidade

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CIÊNCIAS SOCIAIS
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To Maria Amélia da Silva Machado Teixeira,
the love and loss of my life.
It was legendary.

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Abstract

There is a well-established connection between women and the climate change process, indicating that persons of the female gender are more likely to suffer from extreme climate events. Moreover, other theories suggest that women may have a higher ability to manage and care for complex systems such as diverse natural ecosystems. The transition to a sustainable energy system is considered the key to unlock many of the solutions to a more sustainable society, as energy is a growing need and the biggest driver of fossil fuel burning. With a focus on understanding how support for gender equality may also lead to a more sustainable energy system, three econometric models were estimated to determine the impact of women's empowerment in the two different strands of the sustainable transition of the energy system: energy efficiency and energy transition. To estimate this effect, we employed a panel data framework.

Although the estimated effect of female empowerment in the transition to a sustainable energy system is not always statistically significant, some results indicate its clear impact on it, particularly when it comes to the adoption of mitigation and adaptation technologies such as renewable energies. Consequently, the results support the hypothesis according to which female empowerment – through the variable Female Empowerment Index – has a direct impact on the transition to a sustainable energy system.

Keywords: energy system; female empowerment; energy transition; climate change

JEL Codes: Q2, Q3, Q4

Resumo

Há uma relação estudada entre as mulheres e as alterações climáticas, segundo a qual pessoas do sexo feminino incorrem numa probabilidade superior de sofrer com eventos climáticos extremos. Adicionalmente, outras teorias sugerem que as mulheres poderão ter uma habilidade superior para gerir e cuidar de sistemas complexos tais como os ecossistemas naturais. A transição para um sistema energético sustentável é considerada a chave para desbloquear muitas outras soluções que construíram uma sociedade mais sustentável uma vez que a crescente necessidade energética é a maior causa para a queima de energias fósseis. Tendo como foco principal perceber de que modo apoiar o empoderamento feminino pode levar a um sistema energético mais sustentável, três modelos econométricos foram estimados de modo a determinar o impacto do empoderamento feminino em duas vertentes diferentes da transição para um sistema energético sustentável: eficiência energética e transição energética. Para estimar este efeito, foi aplicada uma metodologia de dados em painel.

Apesar de a estimação do efeito do empoderamento feminino na transição para um sistema energético sustentável não ser sempre estaticamente significativa, alguns revelam um impacto claro no processo. Em particular, no que diz respeito à adoção de tecnologias de mitigação e adaptação tais como energias renováveis. Consequentemente, os resultados suporta a hipótese segundo a qual o empoderamento feminino tem um impacto na transição para um sistema energético sustentável.

Conceitos: sistema energético, empoderamento feminino, transição energética, alterações climáticas

JEL Codes: Q2. Q3, Q4

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1. Introduction

The Industrial Revolution placed energy production and consumption at the center of contemporary society, allowing for unprecedented economic growth and development opportunities. Nevertheless, the increasing demand for energy, and for the resources to produce it, created one of the more notable problems identified in the 20th century – climate change. Despite the existence of other factors, the scientific consensus is clear: the main driver of climate change is the burning of fossil fuels, namely coal, oil, and natural gas. In particular, in 2021, the energy sector – where the production is still based on fossil fuels – was responsible for 75% of global annual Greenhouse Gas (GHG) emissions (Climate Watch, 2024). Over the last decades the consciousness of society about climate change and its impacts increased, leading to the realization that the current consumption pattern, particularly the one carried out by developed countries, is not sustainable and, thus, must be altered.

Given the several catastrophic scenarios predicted by reputable specialists and organizations, several programs have been launched to accelerate the implementation of mitigation and adaptation strategies to ease climate change impacts. The principal aim of these strategies is to limit the amount of GHG emissions, focusing on the transformation of the current energy system into a clean energy system based in renewable energy sources. The Paris Agreement reflets this desire, with its overarching goal of limiting the mean global temperature increase to 1.5ºC above pre-industrial levels, through the reduction of GHG emissions. This aspiration is also echoed in the United Nations Sustainable Development Goals (SDG), namely Goal 7: Affordable and Clean Energy and Goal 13: Take urgent action to combat climate change and its impacts. SDG7 aims to guarantee worldwide access to modern and reliable energy and the expansion of renewable energy to reduce the dependence on fossil fuels, along with a considerable increase in energy efficiency. (United Nations, 2023a) The SDG13 urges the populations and governments to take urgent actions to combat climate change by studying the subject and disseminating information about it, as well as, by implementing strategies to reduce GHG emissions, therefore including the creation of a sustainable energy system. (United Nations, 2023b)

Nevertheless, achieving a sustainable energy system implies not only switching energy sources, but also the guarantee that the energy transition is just and equitable across all social groups. The impacts of climate change do not affect all people with the same intensity, with people in vulnerable conditions – originated by social, economic, geographical or health factors – suffering more intense consequences than the remaining population. Gender inequality, rooted in contemporary society, is an example of a vulnerability factor. For instance, according to the United Nations (2022), the negative effects of extreme weather events have a stronger impact on women's lives when compared to men's.

The justice of the energy transition is an often overlooked topic when deciding policies on how to establish an energy system reliant on renewable energy sources. However, the two topics are not incompatible, as they may seem at first glance. For instance, the Feminist Political Ecology theory developed by Rocheleau, Thomas-Slayter and Wangari (2006) states that there are real gender differences when it comes to the interpretation, responsibility and interest taken in nature and the environment. These differences are rooted in the social interpretation of biology and the roles attributed to each gender in the respective social constructs, which provides the female gender with a better capacity to deal with complex systems, such as ecosystems and ecological problems. The book "Drawdown: the most comprehensive plan ever proposed to reverse global warming", edited by Hawken (2017), revealed that one of the most effective strategies to reduce CO_2 Equivalent emissions is to increase the investment in female education, as this will reduce the number of births and limit population growth.

Despite the existence of several studies focusing on the impact of women's empowerment on the reduction of CO_2 Equivalent emissions, most of them focus on the reproductive aspect of women's lives, neglecting how other aspects of Female Empowerment – such as freedom of action, access to ruling positions or the financial market – may impact the climate change combat. Additionally, most of these studies use a descriptive methodology, and econometric models to quantify the relation between two variables are rarely applied (Project Drawdown, 2022). This dissertation focuses on filling that gap, by analyzing the impact of several domains of women's empowerment in the transition to a sustainable energy system. As climate alterations occur both in time and space, the methodology consists of applying simple econometric panel data models to a curated database encompassing countries from all continents across a timeframe of 20 years.

This dissertation aims to answer the following question: what is the impact of women's empowerment in the transition to a sustainable Sociotechnical Energy System? Accordingly, the defined goals for the project consist of identifying whether or not selected aspects of female empowerment have an impact on the transition to a sustainable Sociotechnical Energy System; for detected positive relationships, the objective is to understand the type and dimension of the generated impact.

The next sections are divided as follows: Section 2 provides a Literature Review of the topic; Section 3 describes the methodology and variables used in this study; in Section 4 the estimation results are presented and analyzed; the final section, Section 5, registers the conclusions of the study, while also identifying the weaknesses of the project and indicating new research paths that may derive from it.

2. Literature Review

2.1 Energy System

Despite the most recent efforts to implement more renewable sources of energy, fossil fuels still supply the majority of the necessary primary energy – energy before any transformation – in all world regions. Figure 2.1.1 shows how the different energy sources are used globally.

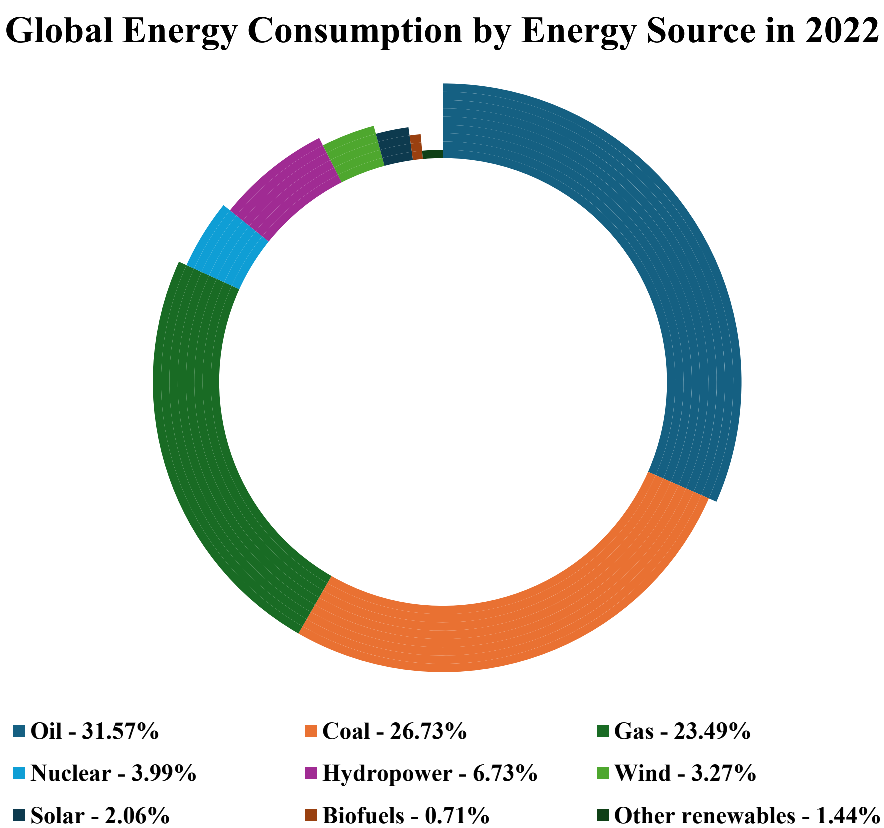

Figure 2.1.1: Energy Consumption by source in 2022 (World level)

In 2022, fossil fuels represented more than ¾ of all energy sources consumed, while renewable energy sources accounted only for 14.21% of all energy consumption at world level. It is important to note that almost half of the renewable energy consumed derives from Hydropower technology (6.73%). Nuclear energy – which is considered a low-carbon energy source, not being classified as renewable –, represents a small, but considerable amount of energy – 3.99%.

The usage and implementation of renewable energy is expanding both in developed and developing countries, with a recent boost triggered by the current increase in fossil fuel prices and the energy security threats arising from the wars (International Energy Agency, 2023a). In the Sustainable Development Goals Report of 2023, it is stated that between 2015 and 2020, the percentage of renewable sources in the final energy consumption increased by 2.4 percentage-points (pp). The increase was more pronounced in the electricity sector (around 5.3 pp) and less in the transport (0.8 pp) and heating (1 pp) sectors (United Nations, 2023c). Furthermore, in the report "Renewable Power Generation Costs in 2021", by International Renewable Energy Agency (2022), it was revealed that renewable energy has been gaining traction, particularly solar and wind sources, not only by a reduction of costs in energy production, but also by the reduction of costs and timeframes in deployment, making them the preferred methods to expand energy production capacity. This, therefore, constitutes a turning point in the financial advantages of investing in renewables. Consequently, under the current circumstances, it expected that in the next years the investment and deployment of renewable energy – particularly wind and solar – will increase considerably in the biggest world economies, with Europe leading the group, followed by the United States, China and India (International Energy Agency, 2023a). This is in line with the conclusions of Diezmartinez (2021), who considered wind and solar as the renewable energy technologies with the higher diffusion rates.

Regardless of recent achievements, it is commonly accepted that current efforts are still not enough (York and Bell, 2019; Johnstone et al., 2020; Marahatta, Bhattarai and Devkota, 2022; and Devkota *et al.*, 2022). Particularly, York and Bell (2019) describe how renewable energy still fails to actually replace other energy sources. The authors distinguish between Energy Addition – the development of infrastructure to expand the production of a certain energy type – and Energy Transition – the replacement of the current energy production sources by more sustainable methods. By analyzing the absolute values of energy produced by each source, York and Bell (2019) note that the use of all energy sources (whether renewable or not) has grown over time. Essentially, the addition of new energy production methods allowed an increase in global consumption of energy, instead of an actual energy transition to a sustainable energy system. This statement is not a surprise. A study conducted by Barbir (2009) explored the decreasing consumption of energy seen in some developed countries, which was often attributed to improvements on energy efficiency. Barbir (2009) noted, however, that the main cause was the movement of energy-intensive industries from developed countries to developing countries, concluding that the global consumption of energy was in fact increasing.

2.1.1 The Energy System as a Sociotechnical System

Given the prominent place conquered by the energy system in human society, scholars in all academic fields have dwelled on the subject and its implications. Several perspectives were developed to define the phenomenon and its sphere of influence. One of those perspectives, which emerged in the innovation studies discipline, was presented by Geels (2004). The author considers the energy system as a sociotechnical system, which the author defines as including the connections between the elements that are necessary to perform all societal functions, based on three technology-based subfunctions: production, distribution and usability. These systems are a result of the action of social groups, whose behavior is guided by institutions. The realization of each societal function entails the technology itself, and all customer practices, public policies, business model, culture, markets and infrastructure that surround it (Geels, 2019).

Geels (2004) states that the existing connections between technological innovation, social groups and institutions are a dynamic relation that consists of mutual adaptations and feedback. This dynamic can be explained through the Multilevel Perspective (Rip and Kemp, 1998; Kemp et al., 2001; Geels, 2002a; Geels, 2002b) – which describes how the innovation process occurs within the sociotechnical system. Three levels are present in the process: first, the niche, where radical innovations appear, and the innovation environment is fast paced. Innovations with higher potential are then captured by firms and established agents in the level above, which is the regime. The regime is the current sociotechnical system, where innovations are incremental and occur due to external pressures or technical problems and consequently transformation is slow. Therefore, the regime is considered as dynamically stable due to phenomena such as increasing returns to scale, path dependency (Dosi, 1992) or carbon lock-in, defined as the continuous use of processes and infrastructure dependent on fossil fuels (Unhru, 2000). The last level is known as landscape and it describes the exogenous structure of the sociotechnical system, including elements such as economic policies, wars or climate change. At this level, change may occur in a sudden way or through small changes over a longer period of time.

This perspective coexists with others that investigate the alterations needed in fundamental systems – such as energy, agriculture or mobility – to promote and resolve a sustainable transition. Nevertheless, and while supporting some valid criticisms, the Multilevel Perspective has gained a relevant position in the sustainability framework, being expanded by several scholars, particularly in social science disciplines, that recognize the importance of the cultural environment to the dissemination of an innovation: positive visions on a new product will help attract customers, investors and the overall legitimation of the invention, while a society that adopts a negative position will focus on the detrimental aspects of the innovation, inhibiting its development. This has been the case for several sustainable innovations related to the energy sector such as carbon storage, biofuels or wind turbines (Geels, 2019).

2.1.2 Energy Transition and Energy Efficiency

Gunnarsdottir *et al.* (2021) reviewed the concept of sustainable energy development and how it evolved over time. Since the release of the "*Our common future*" by Brundtland (1987), the energy system has been considered a key player in attaining sustainable development. Only in 2000, however, did the concept of sustainable energy development emerge, stating that the energy system should be able to respond, not only to the needs of the current generation, but to future ones' too. The authors describe sustainable energy development as having five main goals: to help attain sustainable development, to provide global access to affordable modern energy services, to create a sustainable energy supply chain, to construct a sustainable energy consumption model, and to guarantee energy security worldwide. Gunnarsdottir et al. (2021) highlight the third and fourth goals, creating a sustainable energy supply and consumption model, as these relate to two significant sustainable energy topics – energy transition and energy efficiency. Smil (2017) defined energy transition as the alteration of the base structure of the primary energy supply chain, a metamorphosis from the current system – reliant on fossil fuels – to a new state, based on renewable energy sources.

Bhattarai, Maraseni and Apan (2022) review the factors driving the energy transition, identifying several essential areas of action. The first one is technology, as it is still necessary to improve existing renewable energy technologies, as well as develop better energy storage options. The second is the investment in renewable energy-generation capacity: the more financial resources a country has, the easier it will be to research and build the needed infrastructure. Consequently, the setup of the energy market of each country also plays a defining role, with renewable-energy price considered one of the strongest tools to promote the Renewable Energy Transition (also referred as RET). However, to use this strategy, it is necessary to invest in new infrastructure, as most countries are still dependent on fossil fuels. This can be economically damaging, particularly to all fossil fuel-producing countries, who at the same time are some of the most polluting, powerful, and influential countries in the world. This duality underscores the importance of promoting an economically fair and just transition. The remaining factors relate to government action, applied policy instruments and social acceptance of the transition. Policy instruments are, in many circumstances, the first step toward the adoption of RET. For example, Johnstone et al. (2020) refer that the process of Energy Transition is not spontaneous, requiring different political measures to promote it. These instruments vary according to each country's geographic characteristics and geopolitical framework.

The variety of country policies towards the RET was highlighted by other authors such as Bigerna, Bollino and Pollinori (2021), who analyzed the heterogeneity of RET across different countries and regions, stressing Europe's leading role as the center of study and information production about energy transition technology and policies. Different studies, such as Gümüş (2015) and Shahzadi *et al.* (2021), demonstrated a positive correlation between investment/research in RET and economic growth, illustrating one of the economic advantages of promoting RET. Regarding this topic, Bhattarai, Maraseni and Apan (2022) stress the importance of sharing knowledge and information between nations, since not all countries have the same capabilities, allowing for a more efficient and just transition.

The last factor driving the energy transition, according to Bhattarai, Maraseni and Apan (2022), is the role society plays in obtaining policy success: not only by supporting the energy transition and saving energy, but also through the integration of the new values necessary to achieve a sustainable lifestyle such as equity, education, less consumerism and higher care for the environment.

Although there has been a greater focus on renewable sources for the energy transition, energy efficiency is an important part of reaching emissions targets and environmental goals. Energy efficiency can be defined as the use of a smaller amount of energy to produce the same amount of output, either a product or a service (Patterson, 1996). International Energy Agency (2019) estimates that around 40% of the reduction needed in CO_2 Equivalent Emissions – to achieve the

Sustainable Development Goals and the Paris Agreement targets – can be achieved through policies focused on energy efficiency, making it an essential part of achieving a sustainable energy system.

The process of increasing energy efficiency can take several forms, such as using fewer resources in production, improving product quality to make it last longer, increasing the capacity of a product without additional use of other resources, or creating better ways to end product life, such as upcycling or recycling components. Queck *et al.* (2019) suggests a two-fold impact: on one hand, the fewer resources needed to produce energy, the more sustainable the energy system will be; on the other hand, although renewable energy does not produce as many CO_2 emissions as fossil-fuel energy, it is not free of environmental and health risks, such as land use changes, poisoning from toxic minerals, or alteration of river flows due to dams, which a greater level of energy efficiency could help avoid. Furthermore, energy efficiency requires new technologies and considerable investments, which lead Gräfstrom (2018) to state that the trade in knowledge and information, between richer countries and middle to low-income countries, is essential to improve efficiency levels.

When mentioning energy efficiency, it is important to mention its potential downside – the rebound effect. The rebound effect was acknowledged early on by the Jevons Paradox – The Coal Question (1865) as mentioned in Gillingham, Rapson and Wagner (2016). The authors define the rebound effect as the percentage of energy efficiency that is "lost" because of consumer and market responses: since the product is more efficient, it will be used more, reducing the energy saved due to the energy efficiency improvement. The authors distinguish between two types of efficiency gains: zero-cost breakthrough – when energy efficiency is the only change in the product, that is the other attributes remain constant; and policy-induced improvement – when the energy efficiency occurs simultaneously with a change in other attributes of the product, which may lead to new uses of the product and a reduction in price. In the first case, the reaction of the market and consumers is considered a pure rebound effect, while in the second case the rebound effect may be affected by other factors such as the new product price. The rebound effect may have a direct component – when energy efficiency alters the market consumption of that product; and an indirect component – when the increase in energy efficiency of a product leads to alteration in the consumption of other products.

Hence, the rebound effect must be considered when formulating policies and innovations in the energy sector. However, it is important to note that there is no evidence that supports the claim that the rebound effect fully offsets the positive gains of energy efficiency, indicating that investment in this area should continue (Gillingham et al., 2016).

2.2 Women's empowerment: definition, theories, and the connection to climate change combat

The advance of climate change consequences has made clear that its impacts are not neutral between social groups and across the globe. Vulnerable social groups such as children, women, elderly, migrants, people of color and people with disability are not only more prone to suffering from climate alterations, but also in case of occurrence these social groups will face worse outcomes (International Panel on climate change, 2014). The impact will be greater when these vulnerabilities are combined between each other, and when associated to other factors such as economic difficulties, geographical characteristics, cultural background, religion, or political regime – this process is known as intersectionality.

Women are the largest of the vulnerable groups, and one that has a lot to lose with the increased recurrence of extreme weather events: the United Nations (2022) considers that climate-related hazards increase the gender inequalities present in a society, in particular those related to women's education, health, rights, early marriage and gender violence, as well as socioeconomic condition. This impact is rooted in the current gender inequality and defined societal roles, and it varies with other geographical, societal and economic factors, with females in lower and medium income countries being the most vulnerable (United Nations Women, 2022). Nevertheless, that are several research branches that conclude that, when empowered, women have a great potential to help solve the climate crisis, contributing to both mitigation and adaptation strategies. Both of these topics – how women are more vulnerable to climate alterations and how they can help attenuate those circumstances – will be developed in the following sections.

It is important to note that even though gender issues are often associated to the biological male/female dichotomy; this is not an accurate representation of the concept. The World Health Organization (2022) defines gender as the characteristics of women, men and children of all ages that are socially constructed. These characteristics include societal norms, behaviors and roles associated to each woman, man and child, as well as relationships developed with each other; they vary according to each culture and mutate over time. The concept of gender creates a hierarchy, which generates inequalities that can associate with other social and economic inequalities –

intersectionality. Although understanding and supporting all gender forms and dynamics, this dissertation will focus on women's empowerment and the role women all over the world may play in combating climate change.

2.2.1 Female empowerment: a battle with many fronts

The European Institute for Gender Equality (2022) defines empowerment of women as the "process by which women gain power and control over their own lives and acquire the ability to make strategic choices", dividing it in five main components: the right to access resources and opportunities; the right to decide over their own lives; the right to have control over their own choices, both inside and outside the family context; women's perception of self-worth; and the possibility of exerting influence in the direction of social change. The same source indicates several ways to support the process of women's empowerment, namely women's education and formal training, transformation of male-dominated structures and institutions, reinforcement of women's self-worth, their legal right to choose and the increase of female control over resources.

Anderson (2022) performs an analysis on the state and evolution of female empowerment, stating that despite the major efforts to achieve gender equality, gender differences are still prevalent. The author considers that in the current context, gender equality is not only a goal in itself, but also a pathway to combat other global problems such as climate change or poverty. The process of female empowerment is mostly reciprocated, meaning that an increase in one component of women's empowerment, such as working conditions, will lead to an improvement of other components, for example the decision-making power in the household. Through her research, Anderson (2022) concludes that a direct relationship between female empowerment and declining poverty is yet to be proven, but it is possible to see a relationship between gender equality and economic development: the increase in female education and better access to working conditions is followed by a decrease in the number of births and an increase in economic growth. This relationship is verified both in developed and developing countries, with the exception of countries still dominated by a stigma attached to working women. The author emphasizes that women have different preferences than men in economic terms, which leads them to make higher investments in their children's education, thus generating more development in the subsequent generations.

This idea is supported by previous studies, namely Seguino and Floro (2003), who concluded that women with access to paid labor have more bargaining power within the family, resulting in higher savings and productive investments. More recently, Falk and Hermle (2018) noted that, since economic preferences shape human behavior and decisions, the difference between women's decisions and decisions expressed by men increases with the level of development of the country. This is a direct result of the freedom of choice women benefit from as the level of development increases, which allows them to express their preferences better.

In their book "Poor Economics", Nobel-prize winners Duflo and Banerjee (2011) analyze power when negotiating the number of children in a marriage. They express that this power is subject not only to the level of education of women, but also to laws, social norms, and religious practices. In most of the least developed areas of the world, contraception is easily available, however this is not enough to make people adopt it. A study carried out by the authors in Lusaka, Zambia, revealed that women who were able to leave the house without their husbands were 38% more eager to adopt contraceptives measures than women under purdah – a custom that prohibits such outings. The same book refers the work of Munshi and Myaux (2005), who concluded that in villages in Matlab, India, where there was a nurse available for family planning consultation, women were more likely to use contraception if the other women in their religious circle had also been using it in the previous six months. Both Hindu and Muslim women had the same access to the nurse and to contraceptives, yet only when the method was adopted within each religious circle would the women within that religion use it – the communities did not have influence over each other. This indicates that the decision to reproduce does not belong solely to the couple.

2.2.2 Women´s empowerment and environmental protection: a long-lasting connection

In the last quarter of the 20th century, several schools of thought attempted to analyze the relationship between gender and the environment. Based on these theories, Rocheleau, Thomas-Slayter, and Wangari (1996) introduced Feminist Political Ecology – a new framework that describes the relationship between environmentalism and gender, including its interaction with class, race, age, ethnicity, and nationality. The authors argue that women and men perceive ecological problems in different ways, and consequently have different approaches towards them. In most societies, nowadays and throughout history, women's roles are related to providing, caring for, and managing basic needs, such as food, health, child and elderly care or resource management. Rocheleau, Thomas-Slayter, and Wangari (1996) consider that these roles women embody allows them to develop their abilities to handle complex systems, such as families or ecosystems, and to prioritize health, environmental protection, and societal wellbeing over profits. Levins (1989), as cited in Rocheleau, Thomas-Slayter, and Wangari (1996), describes the scientific/academic realm as an example of how different gendered perceptions materialize: science is highly fragmented and focused on replication, abstraction, and quantification; as women emerge in this field, they develop new methodologies based on the observation of everyday life, which allows for new lines of thought and key insights. Additionally, Keller (1984), Hynes (1989), Hynes (1991a) and Hynes (1991b) concluded that women in science use methods based on their specific socialization. These views were supported by Candib (1995) who stated that women are more prone to propose and favor holistic approaches to environmental and health problems. Rocheleau, Thomas-Slayter, and Wangari (1996) conclude that gender, and its interaction with other variables such as race, class, culture, or ethnicity, is critical in defining new resource-management techniques, as well as the basis for a society based on sustainable development.

2.2.3 The Women's empowerment effect on climate change combat

While the relationship between gender and climate change is a relatively new research topic, particularly when it comes to the impact of women's empowerment on the energy sector, a few studies indicate that gender equality may have a positive impact on strategies for mitigating and adapting to climate change.

One of the crucial moments in reversing climate change is known as drawdown – the future moment when the volume of greenhouse gases in the atmosphere will cease to increase and instead start to decline. To contribute to this landmark, Paul Hawken (2017) in association with Project Drawdown (2022) released a book containing around one-hundred science-based strategies to reverse climate change. One of the solutions is entitled "Girls' education and family planning", where the authors note that the promotion of long-term education and the use of contraceptive methods among young women and girls will have a direct impact on overall fertility rate and women's health, as well as several positive indirect impacts on the surrounding families, communities, environment, climate adaptation and development context. Project Drawdown (2022) refers that educated women not only have fewer children, but also have more tools – such as economic power, knowledge and decision-making skills – that enable them to deal with structural problems such as poverty, gendered violence and climate hazards. This is particularly important for low and medium-income countries where women and girls are more vulnerable. The project estimates that investing in this solution will reduce or capture around 68.90 Gigatons of CO_2 equivalent emissions, making it one of the best ways to mitigate and adapt nations towards climate change.

A similar perspective is also endorsed by Regeneration (2023a), an initiative that describes a set of interconnected actions and responses for individuals, groups or governments which could lead to a reduction in CO_2 equivalent emissions of 45% to 50% by 2030. The promotion of girls' education would result in a decrease in poverty, and a partial reverse of patriarchal rules, which consequently would lead to healthier communities, higher resilience to climate shocks and more effective conservation and environmental protection, as women are more prone to prioritize these themes. Regeneration (2023a) also mentions that the main reasons female education is still overlooked are its cost, fundamentalism, and patriarchy.

Kwauk and Braga (2017) studied the impact of the number of years of girls' education on a country's capacity to adapt to new climate conditions (measured by the ND-Gain Index, which measures a country's vulnerability to climate change, when compared to its capacity to adapt to it). The authors concluded that for each additional year of girl's schooling, a country's resilience to climate change increased by 3.2 percentage points (on a scale from 0 to 100). Kwauk and Braga (2017) conclude that achieving gender equality is essential to an effective combat of climate change. Therefore, increased support for women's reproductive rights is essential, and women should receive further encouragement in dealing with climate-related problems.

However, and despite of extreme importance, female access to education and reproductive health is only a small part of women's possible contributions to climate change combat. A good example is women's access to political organizations or government positions. In the past two decades, different studies concluded that countries with more women in the government are more capacitated to deal with climate change. Based on the foundations laid by the Ecofeminist movement, Norgaard and York (2005) established a positive relation between the number of environmental treaties a country ratified and the percentage of women in parliament. In a later study, Ergas and York (2012) proposed the hypothesis that in countries where gender equality is higher, the environmental impact will be lower when controlling for other factors. The authors performed a quantitative analysis of women's political status and CO_2 emissions per capita across different nations, showing that emissions are lower in countries where women have higher political status. Female political representation may be one of the keys for more effective and fruitful climate adaptation and mitigation measures.

Recently, McGee *et al.* (2020) studied the relationship between gender equality, economic growth and CO_2 emissions with the goal of demonstrating that alongside the political sphere, women's empowerment in the health and economic components also plays an important role in reducing environmental degradation. The authors established two main points: that economic growth is connected to the increase in CO_2 emissions, and that income inequality is also associated to an increase in CO_2 emissions. By performing a fixed-effects panel data regression in 140 countries, where national CO_2 emissions (metric tons) per capita from the burning of fossil fuels and cement is the dependent variable, and GDP per capita in constant 2010 U.S Dollars and Gender Inequality Index (GII) are the main independent variables, McGee *et al.* (2020) concluded that higher gender inequality leads to a stronger coupling between economic growth and CO_2 emissions, and that this relationship is stronger in less developed countries.

Clancy and Feenstra (2019) performed a deep and thorough study of the relation between women, gender inequality and the energy transition in the European Union. Energy is one of the pillars of modern society, and men and women do not always have equal access to, nor influence, the energy sector. Based on a study of the European Institute for Gender Equality (2016, as cited in Clancy and Feenstra, 2019), the authors consider four gender gaps within the sector. The first is the gender gap in energy access: women are more likely to experience energy poverty at some point in their lives than men, while also having more difficulty reaching positions of influence in the sector (more than 20% of the women in the sector are in low-level administrative positions). The second gender gap is related to the renewable energy labor market, where women represent a smaller part of the working force than men. Furthermore, in the European Union the number of women graduating from STEM (Science, Technology, Engineering and Mathematics) courses is almost half the number of men, reinforcing disparities later in the labor market. The last gender gap is about decision-making power, as women have less access to positions of power within and outside the sector – for example, women represent only 6% of ministerial positions related to energy policies and, both in their personal and professional lives, do not have the same influence on which energy sources to invest in or how to manage current resources. Clancy and Feenstra (2019) consider that women's impact on energy transition and efficiency happens under three roles: as professionals, as consumers and as decision-makers. To promote female action in the transition to a sustainable energy system, the authors suggest that women's contributions to STEM, either academic or professional, should be advertised. Particularly, in the energy sector, the support of female contributions should also be emphasized in the scope of Corporate Social Responsibility, and companies should promote learning programs for environment related subjects.

Empowering women within the energy working sector is an important part of promoting a sustainable transition in the sociotechnical system. The International Energy Agency (2022) focused on the role energy companies have in determining labor wages, and how gender and capabilities impact corporate results, across five European countries. As energy companies present higher profits than firms from other sectors, they have a higher ability to define wages, select employees and provide benefits. The study notes that energy-sector companies are male dominated, with women representing 20% less of the workforce when compared to men, and that it presents a larger gender wage gap – around 1 percentage point higher – when compared to other sectors. The study also demonstrated that women tend to switch energy sector jobs for positions in other sectors where they have higher negotiation capacity and earn higher wages. The opposite occurs in the case of male employees.

Another topic that relates energy and gender is cooking. It is estimated that more than half of black carbon – which is a thousand times more polluting than simple CO_2 – emissions originate in actions to heat households and cook. This is a common problem in developing countries, especially in poorer areas. Despite affecting everyone's health, causing around 4 million deaths per year, women and girls suffer more than men, as in many circumstances they are in charge of household tasks, namely cooking. This is not a new topic: since the 1950's several projects have tried to deliver modern cooking devices to families. Unfortunately, access to clean stoves did not result in the expected improvements in terms of air pollution, gender dynamics and nature protection, as many of the basic behaviors were not changed. Therefore, it is necessary to better understand communities and their needs to determine what strategies are best to tackle this problem (Regeneration, 2023b).

2.3 Women's empowerment and climate change combat: the weight of current context

The processes of empowering women and combating climate change depends on several societal factors and the characteristics of each country, which may be difficult and slow to change. Some examples can be the political context of a country – whether a democracy or a dictatorial regime – , the religious background – religion tends to support the patriarchy and women oppression –, the central pillars of each economy – whether a country depends on fossil-fuel exports or not –, and the level of economic development of each nation – as most strategies to empower women and mitigate/adapt climate change require major investments. It is also important to consider that climate-induced disasters tend to aggravate the geographical, economical, and political conditions of women causing a regression in the progress made (Benjamin and Thomas, 2020).

McGlade and Ekins (2015) state that, to limit global warming to 2ºC in 2050, it would be necessary to maintain most of the current fossil-fuel reserves untouched: at least 5% of Natural Gas, 30% of Oil and over 80% of Coal reserves. Welsby *et al.* (2021) indicate that countries who rely heavily on fossil fuels exports – for some countries such as Saudi Arabia or Iraq it represents more than half of governments revenue – would need to diversify their economies to low-carbon sectors in record time. This may be slightly easier for developed countries, yet for developing countries it is very unlikely to be achieved. The authors consider that developed countries should take the lead, creating not only adaptation and economic frameworks that the less developed countries could adopt. According to the Paris Agreement, this is a responsibility of the more developed parties, alongside providing the financial resources for the implementation process in low-income countries – this is the "common but differentiated responsibility and respective capabilities" principle defined as part of the UN Convention (UN Framework Convention on Climate Change, 2024).

Sustainable Development Goal 7, "Affordable and Clean Energy", shows positive developments, with more investment in clean energy and with the rates of electrification and access to clean fuel increasing in the last few years – from 87% to 91% and 64% to 71%, respectively (United Nations, 2024). Nevertheless, and as agreed in COP 28, this effort is not sufficient, and all countries need to make an additional effort to keep the global temperature increase to 1.5ºC. Therefore, it was created the global stock take: a document, signed by all parties, that recognizes the need to phase out fossil fuels more effectively, that renewable energy capacity must triple, and that energy efficiency must be duplicated to meet the Paris Agreement targets. This document also contains how the countries must guide themselves to design and implement their climate action plans, mostly focusing on the phase out of the fossil fuels and respective subsidies, attributing responsibility to developed countries to lead and finance the way (UN Framework Convention on Climate Change, 2023).

Despite gaining popularity in the last few decades, policies aiming to improve gender issues are far from sufficient. An analysis performed by OECD-DAC (2019), about aid programs dedicated to female empowerment, concluded that these only represent 4% of all the financial aid reported, being disproportionately low regarding agricultural, clean water and energy access or rural development. Additionally, the report considered that 62% of all financial aid does not consider gender as an applicability factor (OECD-DAC, 2019). The United Nations Women 2023 Report indicated that "No country has achieved full gender parity and fewer than 1 percent of women and girls live in a country with high women's empowerment and a small gender gap". The freedom of choice and access to the same opportunities as males remains restricted in the 114 countries analyzed, and women only achieve on average 72% of their potential when compared to men, according to Global Parity Index. The report also mentions that human development is not the solution to gender equality, as many countries with high levels of human development display a below-average performance in combating gender issues. The report indicates that it is necessary to actively invest in policies that support women's full potential, such as improved health care, better laws against female violence and promotion of equality in the workplace, parenthood, and education (United Nations Women, 2023).

These findings are in line with the progress report of Sustainable Development Goal 5 "Achieve gender equality and empower all women and girls". The report stated that at the current pace, it would take decades or even hundreds of years to achieve equality – 286 years to end discriminatory practices, 140 years to have equal representation in workplace leadership positions and 47 to have equal gender representation in the national parliaments (United Nations, 2024).

The discussion has highlighted that all these issues have an interconnected nature. Therefore, their connections and interactions is essential to outline a resilient climate agenda for each country.

3. Methodology

The transition of the sociotechnical energy system concerns all social and natural sciences today. Accordingly, the topic can be analyzed through very different lenses and methods, namely, through the point of view of economics. as is the goal of this dissertation. This project uses an econometric methodology (Wooldridge, 2012) to answer the question: "Does women's empowerment have an impact on the sociotechnical transition to a new and sustainable energy system?". In particular, the work analyzes the relationship between the evolution of energy efficiency / energy transition and the evolution of female empowerment.

Since sociotechnical systems, society and nature all change both along time and space, it is important to analyze both dimensions during the research project. Consequently, the ideal type of data is panel data. Wooldridge (2012) defines panel data as "a time series for each cross-sectional member in the data set", allowing the analysis of different variables for various time periods and multiple individuals at the same time. In this dissertation, a balanced panel of 72 countries and 23 variables was assembled, covering a twenty-year period between 2000 and 2019, inclusive. The result is a balanced panel with 16 560 observations.

3.1 Variables

As noted above, the sustainable energy transition has two main dimensions: the evolution of energy efficiency and the transition towards sustainable energy sources (Gunnarsdottir et al., 2021). Based on the distinctive features between the two, three models were formulated using different explained variables to capture a precise outlook on the effects of different female empowerment aspects on these dimensions.

The first model has energy intensity [*enerint*] as its dependent variable. Energy intensity [*enerint*] is defined as the quantity of energy necessary to produce one unit of output and is commonly used as a proxy when measuring energy efficiency (International Energy Agency, 2023b). In this project, the indicator used is the "Primary energy consumption per GDP", from Our World in Data, which measures the value of primary energy used per unit of Gross Domestic

Product (GDP) in kWh/$1 (Our world in data, 2023c). Note that, there is an inverse relationship between energy intensity [*enerint*] and energy efficiency, meaning that when energy efficiency rises, energy intensity decreases.

The second and third models focus on the energy transition perspective. The dependent variable of the second model is the CO_2 emissions per capita [*co2pc*], also from Our World in Data. This variable displays the total yearly emissions of carbon dioxide (CO_2) of each country, originating from the burning of fossil fuels and industry – the land-use change emissions are not considered –, divided by population. It is expressed in tons per person (Our world in data, 2023d). Nevertheless, while CO_2 emissions per capita [*co2pc*] are an important indicator, it cannot capture all efforts made to reach a sustainable energy system, as there is still a large path dependency on fossil fuels (Dosi, 1992) and carbon lock-in (Unhru, 2000). Therefore, the third model has the share of electricity production from renewables [*selectprodren*], from Our World in Data, as its dependent variable. This indicator shows how much of the total electricity produced in a country is created from renewable sources, namely, solar, wind, hydropower, geothermal, waves, tides, biomass and waste. It is a proxy to measure the investment of a country in the creation of a sustainable energy system (Our world in data, 2023e).

The only difference between the models are the dependent variables, since the methods applied and the covariates are the same in all three. The covariates chosen for this study were selected based on two criteria: the first, to capture all the dimensions of women's empowerment as defined by the European Institute for Gender Equality (2022), mentioned in the Literature Review chapter; the second, to control for other factors that may be relevant for the behavior of dependent variables.

Two covariates capture the female condition in access to education, labor markets and positions of influence. The first, female labor force participation rate % [*femlabfpr*], indicates the percentage of female population, at least 15 years old, that is economically active. This was retrieved from the World Bank Database, indicator "Labor force participation rate, female (% of female population ages 15+) (modeled ILO estimate)". The second variable, proportion of seats held by women in parliament % [*seatswomparl*], indicates the percentage of parliamentary seats occupied by women

[1]kWh/$ stands for kilowatt-hour per dollar. It is used to measure the amount of primary energy used to produce a GDP Dollar. In this indicator, the GDP was adjusted for inflation and differences in the cost of living between countries to allow for a correct comparison.

in the respective National Parliament (or equivalent organ). Data was retrieved from the homonymous indicator in Work Bank Database (World Bank Data Bank, 2023).

The female empowerment index [*femempind*] is the covariate selected to showcase how the legal system of each country portrays women's freedom of action and protection. This variable was created during this project as it is described further down in this section. . It can take values between 0 and 1, with 0 representing an extremely conservative posture in basic women's freedoms and protection, while 1 indicates that the country allows women high protection and major freedom of action.

To assess the evolution of female empowerment in factors such as health and cultural context, five more covariates were added. The health component is analyzed through the variables maternal mortality ratio [*matmortr*] and the percentage of access to clean fuel [*acccleanfuelp*]. The maternal mortality ratio [*matmortr*] indicates how many women die from pregnancy-related issues, while pregnant or within 42 days after the termination, per 100 000 live births. This information was retrieved from the indicator "Maternal mortality ratio (modeled estimate, per 100,000 live births)" from the World Bank Database. The percentage of access to clean fuel [*acccleanfuelp*] indicates the proportion of population that uses clean fuels and technologies to cook. It was retrieved from World Bank indicator "Access to clean fuels and technologies for cooking (% of population)" (World Bank Data Bank, 2023).

The cultural aspect was captured by the dominant religion in each country – as in many cases it is a determinant aspect in women's behavior and freedom of action. Three dummy variables were created based on the six dominant religions across the countries and the fact that some countries report to be unaffiliated. Islam Religion dummy [*islamreld*] – assumes value 1 if the country's dominant religion is Islamism, otherwise, it assumes the value 0. Christian Religion dummy [*christreld*] – takes on value 1, if the country's dominant religion is Christianism, otherwise it assumes the value 0. The last dummy Other Religions [*otherreld*], which will be omitted from the econometric models and will act as benchmark for the interpretation of the effects of the other two variables, encompasses the smaller dominant religions or beliefs, namely Buddhism, Folk Religion, Judaism, Hinduism and atheism: if the countries identify with any of these, the dummy assumes the value 1. The listing of dominant religion per country was retrieved from PEW Research Center (2012).

To control the highest number of factors that influence the dependent variables, some additional covariates were included in the model. These will consider factors that already have a demonstrated effect on the three dependent variables such as: the level of economic development of a country, its fossil fuel reserves and respective prices, as well as its geographical region. The indicator Gross Domestic Product per capita [*gdppc*], in US Dollars, from the World Bank Database was used to assess economic development (World Bank Data Bank, 2023). The fossil fuel reserves index [*fossilfuelresi*] – whose formulation is detailed below – indicates how strong the country is in terms of fossil fuel reserves: it varies between 0 and 1, with 0 meaning that the country has no reserves of any kind of fossil fuel; and 1, indicating that the country has reserves for all fossil fuels considered – oil, natural gas and coal. To complete the control on the fossil fuel industry, three indicators were added to cover fossil-fuel prices: oil price [*oilprice*], natural gas price [*natgasprice*] and coal price [*coalprice*]. The prices were retrieved from the Energy Outlook of BP Database that keeps record of the spot price of several global price benchmark (British Petroleum, 2022). The listing of the countries and respective global price benchmark used for each fossil fuel can be found in Annex A. These indicators – *fossilfuelresi*, *oilprice*, *natgasprice*, *coalprice* - are particularly relevant as the existence of these reserves and the prices applied in each country will influence the propensity of the population to adopt a new sustainable energy system. At last, and based on the United Nations world region division, seven dummies were created to indicate the country the geographical area: Europe [*europerd*], Africa and Middle East [*afrmerd*], North America [*noramrd*], Latin America [*latamrd*], South Asia [*southasrd*], East Asia [*eastasrd*] and Southeast Asia [*southeastasrd*]. When the country is in the named region the dummy takes on the value 1, otherwise assumes 0 (United Nations, 2023d). The variable *noramrd* will be omitted from the econometric models and will act as benchmark for the interpretation of the effects of the other six variables.

As stated above, the covariates female empowerment index [*fomempind*] and fossil fuel reserves index [*fossilfuelresi*] are index variables created in the course of this project to help rank and summarize data. The next two paragraphs describe this creation process in greater detail.

The two covariates female empowerment index [*femempind*] and fossil fuel reserves index [*fossilfuelresi*] were created based on the same method: first, a group of variables associated with a common topic was selected; second, these variables were added and the mean values were calculated. As the goal was to summarize the information needed for this study, this process was kept simple. Additionally, since both the index covariates are based on dummy variables, their values will only vary between 0 and 1.

Female empowerment index [*femempind*] is the sum of five dummy variables: domestic violence legislation dummy – which indicates whether these acts are criminalized (1) or not (0); head of household dummy – stipulates if a woman can represent her household (1) or not (0); divorce judgement dummy – specifies if a woman has access to the same divorce conditions as the male counterpart (1) or not (0); travel outside the country dummy – refers to whether the women can travel internationally in the same conditions as men (1) or not (0); and law equal remuneration dummy – which shows if the current country legislation states that males and females must be paid an equal salary for a job of equal value (1) or not (0). This information was retrieved from the Gender Indicators of the World Bank Database (World Bank Data Bank, 2023).

The fossil fuel reserve index [*fossilfuelresi*] is the sum of the three dummy variables indicating if the country has natural reserves of each fossil fuel: coal reserve dummy, natural gas reserve dummy and oil reserve dummy. These variables were retrieved from BP Database (British Petroleum, 2022).

From this chapter onwards, the variables will be referred to solely by their short name, presented between brackets.

3.2 Econometric models

When specifying an econometric model, several covariates are selected to control for factors that may affect the dependent variable. Nevertheless, some factors are not observable and are impossible to control for, such as some country-specific characteristics. In the case of this study, examples could be unobservable cultural characteristics of the agents, such as inherited predisposition to accept change, or the effects of government policies. These may have an impact on the transition from the current energy system to a sustainable one. Such unobserved variables pose a problem to the data analysis process, as one cannot be certain about the possibility of correlation with some of the covariates. This can lead to endogeneity, which occurs when one or more of the independent variables are explained by an unobserved variable contained in the error term $(a_i + u_{it})$, causing the estimator to be inconsistent (Wooldridge, 2010). Below is the formulation of an econometric panel data model, with multiple explanatory variables:

$$y_{it} = \beta_1 x_{it1} + \beta_2 x_{it2} + \cdots + \beta_k x_{itk} + a_i + u_{it}, t = 1,2, \ldots, T \quad (3.2.1)$$

In this model, a_i represents all unobserved time-constant factors that affect the dependent variable, which is known as unobserved individual (country) heterogeneity. u_{it} is denominated as idiosyncratic error – or time-varying error –, constituting the unobserved factors that change over time. The sum of the two $(a_i + u_{it})$ constitutes the composite error term (Wooldridge, 2010).

Several econometric methods have been developed over time to work with panel data, encompassing different perspectives on how to treat the error term. However, only two econometric estimators will be applied in this project: the Fixed Effects Estimator and the Random Effects Estimator. The two methods share the same perspective regarding the idiosyncratic error (u_{it}), assuming strict exogeneity in the sense that $E[u_{it}|x_{it}] = 0$, for every i and t, but have distinct postures regarding the unobserved individual heterogeneity (a_i): the Fixed Effects Estimator makes no assumptions about its distribution, while the Random Effects Estimator assumes strict exogeneity between (a_i) and the covariates in the sense that $E[a_i|x_{it}] = 0$. Since it is not possible to make absolute assumptions regarding the correlation between the unobserved fixed effect (a_i) and the explanatory variables, both estimations will be performed and then tested for statistically significant differences in the coefficients of the independent variables that vary over time (Wooldridge, 2010).

3.3 Hypotheses

The three models were formulated based on the data available and the theories described in the Literature Review chapter. These models will be used to answer the research question, and therefore, each of the models encompasses a hypothesis – an assumption based on the primary argument of the project that will be tested to access its truthfulness.

Hypothesis 1: "Does female Empowerment have a positive impact on the evolution of Energy Efficiency". This hypothesis will be tested by model 1, described below:

$$
\begin{aligned}
enerint_{it} = {} & \beta_1 femlabfpr_{it1} + \beta_2 seatswomparl_{it2} + \beta_3 fememp ind_{it3} \\
& + \beta_4 matmortr_{it4} + \beta_5 acccleanfuelp_{it5} + \beta_6 islamreld_{it6} \\
& + \beta_7 christreld_{it7} + \beta_8 gdppc_{it8} + \beta_9 fossilfuelresi_{it9} \\
& + \beta_{10} oilprice_{it10} + \beta_{11} coalprice_{it11} + \beta_{12} natgasprice_{it12} \\
& + \beta_{13} europerd_{it13} + \beta_{14} afrmerd_{it14} + \beta_{15} latamrd_{it15} \\
& + \beta_{16} southasrd_{it16} + \beta_{17} southeastasrd_{it17} + \beta_{18} eastasrd_{it18} \\
& + a_i + u_{it}, t = 2000, 2001, \dots, 2019
\end{aligned} \tag{3.2.12}
$$

Hypothesis 2: "Does female Empowerment have a positive impact on the evolution of the Energy Transition". To evaluate this hypothesis two models – 2 and 3 – will be used. These models are defined below:

$$
\begin{aligned}
co2pc_{it} = {} & \beta_1 femlabfpr_{it1} + \beta_2 seatswomparl_{it2} + \beta_3 fememp ind_{it3} \\
& + \beta_4 matmortr_{it4} + \beta_5 acccleanfuelp_{it5} + \beta_6 islamreld_{it6} \\
& + \beta_7 christreld_{it7} + \beta_8 gdppc_{it8} + \beta_9 fossilfuelresi_{it9} \\
& + \beta_{10} oilprice_{it10} + \beta_{11} coalprice_{it11} + \beta_{12} natgasprice_{it12} \\
& + \beta_{13} europerd_{it13} + \beta_{14} afrmerd_{it14} + \beta_{15} latamrd_{it15} \\
& + \beta_{16} southasrd_{it16} + \beta_{17} southeastasrd_{it17} + \beta_{18} eastasrd_{it18} \\
& + a_i + u_{it}, t = 2000, 2001, \dots, 2019
\end{aligned} \tag{3.2.14}
$$

$$
\begin{aligned}
& selectprodren_{it} \\
& = \beta_1 femlabfpr_{it1} + \beta_2 seatswomparl_{it2} + \beta_3 fememp ind_{it3} \\
& + \beta_4 matmortr_{it4} + \beta_5 acccleanfuelp_{it5} + \beta_6 islamreld_{it6} \\
& + \beta_7 christreld_{it7} + \beta_8 gdppc_{it8} + \beta_9 fossilfuelresi_{it9} \\
& + \beta_{10} oilprice_{it10} + \beta_{11} coalprice_{it11} + \beta_{12} natgasprice_{it12} \\
& + \beta_{13} europerd_{it13} + \beta_{14} afrmerd_{it14} + \beta_{15} latamrd_{it15} \\
& + \beta_{16} southasrd_{it16} + \beta_{17} southeastasrd_{it17} + \beta_{18} eastasrd_{it18} \\
& + a_i + u_{it}, t = 2000, 2001, \dots, 2019
\end{aligned} \tag{3.2.15}
$$

Table 3.2.4.1: Expected signal of each covariate

	Hypothesis 1	Hypothesis 2	
Covariates	Model 1	Model 2	Model 3
femlabfpr	(-)	(-)	(+)
seatswomparl	(-)	(-)	(+)
femempind	(-)	(-)	(+)
matmortr	(-)	(-)	(+)
acccleanfuelp	(-)	(-)	(+)
islamreld	(+)	(+)	(+)
christreld	(+)	(+)	(+)
gdppc	(-)	(+)	(+)
fossilfuelresi	(+)	(+)	(-)
oilprice	(-)	(-)	(+)
coalprice	(-)	(-)	(+)
natgasprice	(-)	(-)	(+)
europerd	(-)	(-)	(+)
afrmerd	(+)	(-)	(-)
latamrd	(+)	(-)	(-)
southasrd	(+)	(-)	(-)
eastasrd	(+)	(-)	(-)
southeastsrd	(+)	(-)	(-)

4. Analysis

4.1 Descriptive Analysis

In table 4.1.1, it is possible to see the values of Mean, Standard Deviation, Minimum and Maximum, as well as the number of observations, for each of the continuous variables used in this project. Note that the table 4.1.1 and table 4.1.2 are divided in three sections: the first represents the dependent variables, the second the explanatory variables and lastly the control variables.

Table 4.1.1: Continuous variables summary

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
enerint	1440	1.502	0.641	0.359	6.262
co2pc	1440	6.928	5.128	0.198	34.138
selectprodren	1440	30.314	28.699	0	100
femlabfpr	1440	49.822	11.582	10.950	72.135
seatswomparl	1440	20.760	10.850	0	50
femempind	1440	0.814	0.201	0.167	1
matmortr	1440	44.298	83.549	1	567
acccleanfuelp	1440	89.204	21.570	0	100
gdppc	1440	20817.587	21435.099	401.092	123678.700
fossilfuelresi	1440	0.361	0.380	0	1
oilprice	1440	63.840	27.763	22.783	111.670
coalprice	1440	70.472	26.651	27.521	178.058
natgasprice	1440	6.197	2.960	2.373	16.754

In most variables, the Mean value is closer to the Minimum amount, indicating that most observations in the sample are on the lower end of the distribution. Regarding the energy-related variables – *enerint*, *co2pc* and *selectprodren* – this distribution shows the referred description between the countries energy systems: most countries have low energy intensity and/or low CO_2pc and/or low rates of renewable energy production; nevertheless, there are a few countries with strikingly different characteristics. It is also noted that the opposite occurs for most variables related to the female empowerment: *femlabfpr*, *femempind* and *acccleanfuelp*. In this case, the mean value is closer to the maximum amount, indicating that most countries in the sample perform well in these indicators. These findings are corroborated by the standard deviation values that are generally small, signaling that most values gravitate towards the mean, provoking a skewed distribution. This is expected as most countries in the sample are developed countries that perform quite well in the female empowerment and energy intensity indicators but still fall behind in renewable energy production. Table 4.1.2 describes the Skewness and Kurtosis tests for normality – a formal way of assessing the format of the distribution –, supporting the analysis above. The joint test – shown in the last two columns – indicates that for all variables it is possible to reject the null hypothesis – according to which the variables are normally distributed – at 1% level, validating the premise of skewed distributions for all variables in the table.

Table 4.1.2: Skewness and Kurtosis tests for normality

Variable	Observations	Pr(skewness)	Pr(kurtosis)	Adj chi2(2)	Prob>chi(2)
enerint	1440	0.000	0.000	383.310	0.000
co2pc	1440	0.000	0.000	261.820	0.000
selectprodren	1440	0.000	0.000	127.840	0.000
femlabfpr	1440	0.000	0.000	197.100	0.000
seatswomparl	1440	0.000	0.000	69.900	0.000
femempind	1440	0.000	0.000	316.000	0.000
matmortr	1440	0.000	0.000	888.270	0.000
acccleanfuelp	1440	0.000	0.000	514.980	0.000
gdppc	1440	0.000	0.000	341.500	0.000
fossilfuelresi	1440	0.000	0.000	1073.280	0.000
oilprice	1440	0.000	0.000	358.540	0.000
coalprice	1440	0.000	0.000	122.090	0.000
natgasprice	1440	0.000	0.000	225.570	0.000

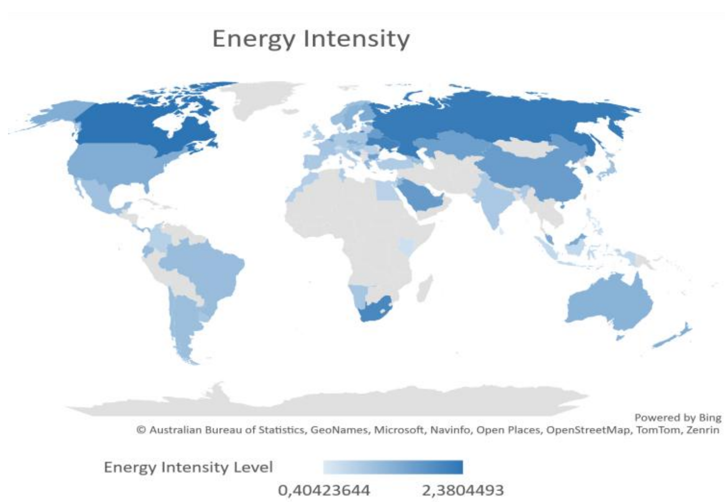

Figure 4.1.1: Energy Intensity around the world in 2019

This can also be verified in maps Figure 4.1.1, 4.1.2 and 4.1.3, where it is possible to see, for each of the variables, the distribution of the countries across the value spectrum in 2019. For the energy variables, the division between the global north and south is clear: countries in the northern hemisphere are much more polluting, with higher rates of Energy Intensity and CO_2 Emissions per capita.

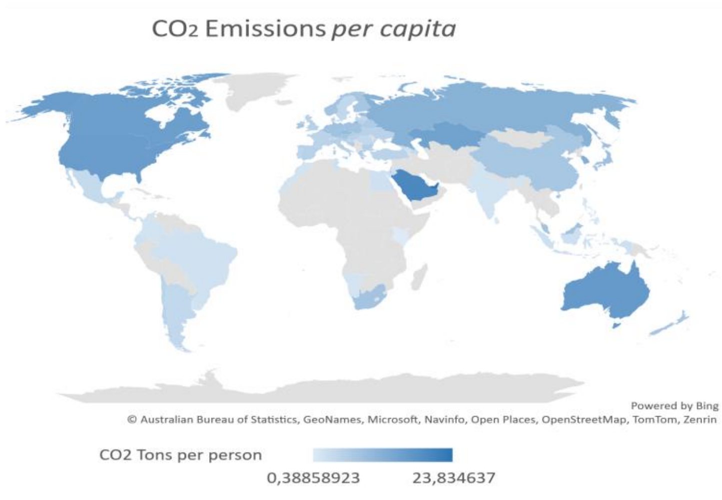

Figure 4.1.2: CO_2 Emissions *pc* around the world 2019

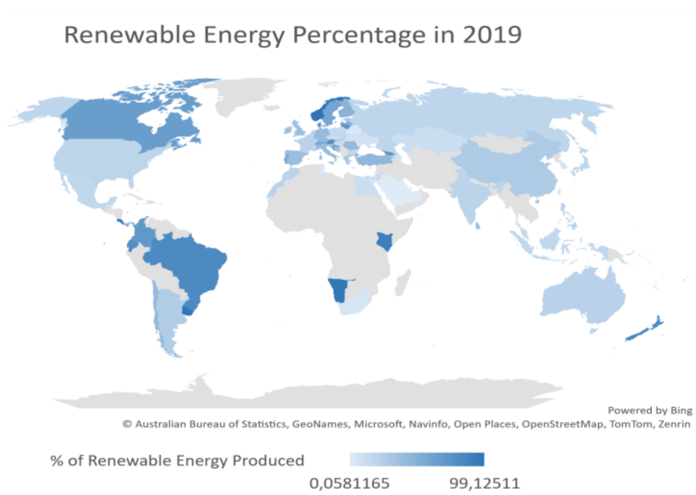

Figure 4.1.3: Renewable Energy Production around the world 2019

Nevertheless, it is important to note that a considerable number of countries in the Southern Hemisphere are quite close to attaining an Energy System based on Renewable Energy; this indicates that the global north is more dependent on Fossil Fuels and subject to the Carbon Lock-in effect than the global South, which started their development later on and, consequently, immediately adopted more sustainable practices.

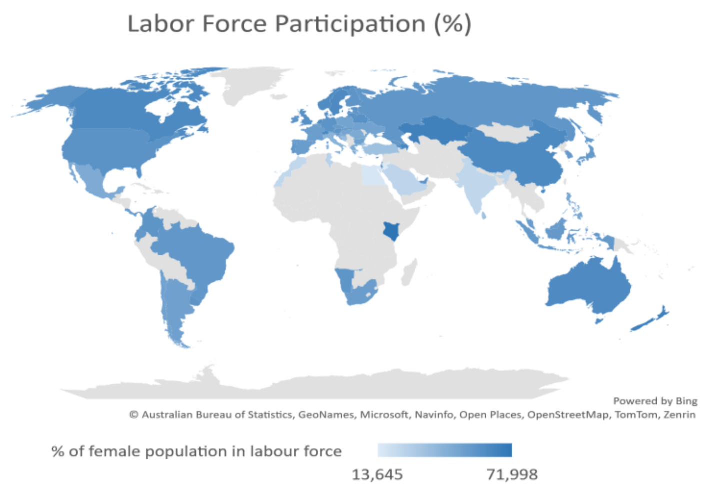

Figure 4.1.4: Female Labor Force Participation around the world 2019

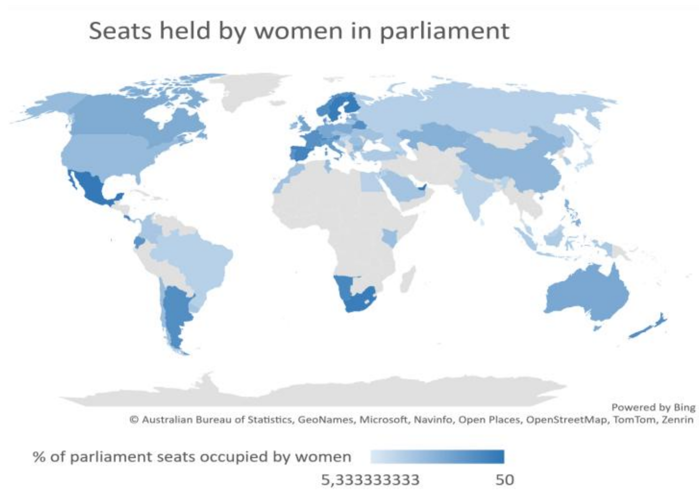

Figure 4.1.5: Seats held by women in parliament around the world 2019

The variable "Seats held by women in parliament" presents a wider variation between countries, contrasting with the other variables. European countries, Mexico, Argentina, Namibia and South Africa present the highest percentages of women representatives in the government, when comparing to the remaining countries in the sample. In this case, the North/ South dichotomy is not perceived, indicating that in this case other factors than access to education, financial and health resources may have a higher impact. One of these factors may be the fact that all these countries have been involved in military conflicts for prolonged periods of time in recent years, causing women to rise and substitute man in important societal roles. It is interesting to note that countries with a strong religious facade present lower values than other countries.

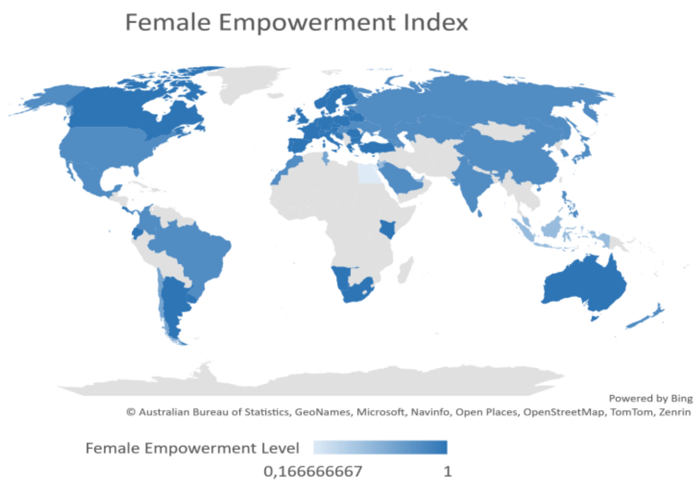

Figure 4.1.6: Female Empowerment Index around the world 2019

Regarding women's empowerment, the majority of countries were in a similar and favorable position in 2019 for variables *femlabfpr*, *femempind*, *matmortr* and *acccleanfuelp*. Nevertheless, it is possible to distinguish between the global North and South. Countries in Africa, South and Southeast Asia, and Latin America show a worse performance in all indicators. Even in the Maternal Mortality Rate map these regions have a slight darker color than the European, North America and Oceanic countries. Again, this is related to the development levels of each country, as countries with more financial and social results invest more in education and in social institutions that support female empowerment practices.

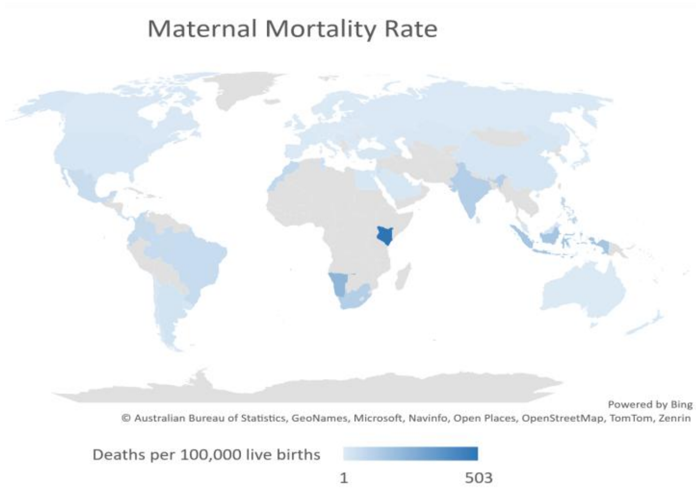

Figure 4.1.7: Maternal Mortality Rate around the world 2019

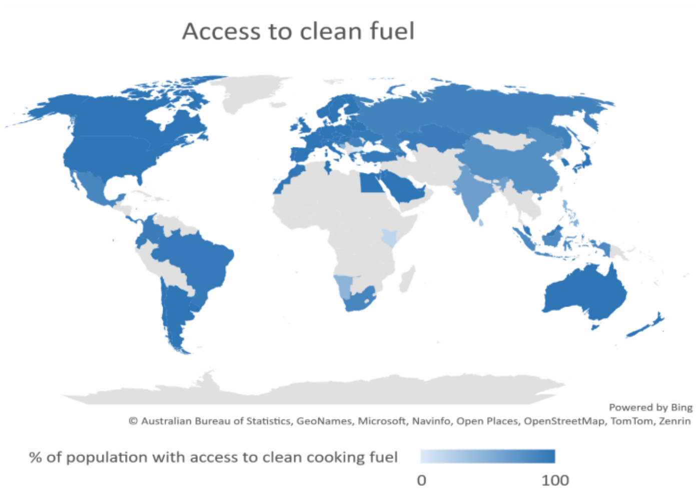

Figure 4.1.8: Access to clean fuel around the world 2019

Associating this result with the analysis of the Figure 4.1.3 poses the question whether the regions performing worse in the women's empowerment indicators also have lower rates of energy production. This aligns with the literature review on the topic – McGee et al. (2020), Ergas and York (2012) and Kwauk and Braga (2017) –, which states that countries with lower female empowerment conditions have higher difficulties in applying sustainable policies.

Figure 4.1.8: Countries present in the sample divided by region

Figure 4.1.9: Countries present in the sample divided by religion

The maps in Figures 4.1.8 and 4.1.9, represent the distribution of the dummy variables that represent the different religions and world regions. The most prominent religion in the sample is the Christian religion, followed by the Muslim Religion, mostly in Africa and the Middle East, as well as in Southeast Asia. Although the countries present in the sample are distributed across the world, there is a higher focus on the American and European continents, as well as Middle East and Southeast Asia regions, since the amount of information reported is higher for these regions.

Table 4.1.3 shows the correlation coefficients between the variables used in the dissertation. Each value represents the correlation between the two variables indicated, with highlighted cells showing the more relevant correlations. The correlations values vary between -1 and 1, with 0 indicating that the variables are not correlated in any way, -1 indicating a perfect negative correlation and 1 indicating perfect positive correlation.

Correlation Matrix	*enerint*	*co2pc*	*femlabfpr*	*femempind*	*matmortr*	*seatswomparl*	*acccleanfuel*	*gdppc*	*fossilfuelresi*
enerint	1								
co2pc	0.467	1							
femlabfpr	0.132	0.133	1						
femempind	-0.112	-0.013	0.513	1					
matmortr	-0.216	-0.385	0.0254	-0.148	1				
seatswomparl	-0.110	0.105	0.343	0.482	-0.126	1			
acccleanfuel	0.203	0.427	0.010	0.067	-0.714	0.194	1		
gdppc	-0.039	0.560	0.304	0.329	-0.348	0.426	0.406	1	
fossilfuelresi	0.131	0.238	0.042	-0.161	-0.008	-0.086	-0.006	-0.035	1
christreld	-0.049	-0.084	0.402	0.542	-0.043	0.383	0.096	0.203	-0.145
islamreld	-0.029	0.040	-0.496	-0.678	0.083	-0.307	0.035	-0.233	0.206
othersreld	0.097	0.070	-0.005	0.004	-0.032	-0.184	-0.168	-0.021	-0.028
oilprice	-0.203	-0.003	0.060	0.185	-0.054	0.158	0.043	0.195	-0.008
natgasprice	-0.085	0.036	0.064	0.125	-0.078	-0.002	-0.080	0.169	0.022
coalprice	-0.154	0.034	0.074	0.204	-0.112	0.120	0.038	0.225	-0.015
selectprodren	-0.336	-0.390	0.276	0.281	0.236	0.219	-0.225	0.037	-0.141
afrmerd	-0.073	-0.028	-0.517	-0.517	0.460	-0.156	-0.160	-0.223	-0.065
latamrd	-0.164	-0.331	0.074	0.019	0.047	0.018	0.028	-0.240	0.071
europerd	0.122	0.152	0.257	0.409	-0.402	0.206	0.303	0.295	-0.199
southeastasrd	0.020	0.036	0.096	-0.143	0.077	0.006	-0.132	0.022	0.111
northamerd	0.192	0.354	0.142	0.086	-0.063	-0.007	0.085	0.193	0.284
eastasrd	-0.189	-0.194	-0.274	-0.026	0.168	-0.202	-0.463	-0.150	0.062
southasrd	0.089	0.083	0.095	-0.015	-0.068	-0.114	-0.035	0.015	0.046

Table 4.1.3: Correlation matrix of all variables

Table 4.1.3: Correlation matrix of all variables (continuation)

Correlation Matrix	*christreldt*	*islamreld*	*othersreld*	*oilprice*	*natgasprice*	*coalprice*	*selectprodren*	*afrmerd*	*latamrd*
christreld	1								
islamreld	-0.685	1							
othersreld	-0.609	-0.161	1						
oilprice	0.004	-0.011	0.006	1					
natgasprice	-0.146	-0.043	0.245	0.620	1				
coalprice	-0.022	-0.042	0.075	0.758	0.696	1			
selectprodren	0.427	-0.312	-0.240	0.008	-0.090	-0.046	1		
afrmerd	-0.379	0.611	-0.152	-0.012	-0.199	-0.120	-0.106	1	
latamrd	0.263	-0.180	-0.161	-0.031	-0.235	-0.146	0.375	-0.171	1
europerd	0.345	-0.294	-0.147	0.026	0.015	0.110	-0.114	-0.425	-0.449
southeastasrd	-0.150	0.151	0.038	0.008	0.318	0.095	-0.068	-0.121	-0.128
northamerd	0.105	-0.072	-0.064	-0.012	-0.094	-0.058	0.038	-0.068	-0.072
eastasrd	-0.273	-0.072	0.447	0.005	0.178	0.054	-0.007	-0.068	-0.072
southasrd	-0.336	-0.089	0.552	0.006	0.220	0.066	-0.141	-0.084	-0.089

Table 4.1.3: Correlation matrix of all variables (continuation)

Correlation Matrix	*europerd*	*southeastasrd*	*northamerd*	*eastasrd*	*southasrd*
europerd	1				
southeastasrd	-0.319	1			
northamerd	-0.179	-0.051	1		
eastasrd	-0.179	-0.051	-0.029	1	
southasrd	-0.220	-0.063	-0.035	-0.035	1

By analyzing the table, it is possible to conclude that there are no strong correlations that could raise caution to the use of variables. Nonetheless, some of the highlighted correlations deserve a deeper look. There is an inverse correlation between *matmortr* and *acccleanfuelp*, which indicates that access to clean cooking fuel reduces the number of maternal deaths per 100,000 habitants, as it reduces the number of toxic elements pregnant women – and people in general – are exposed to. The correlations between the religions – *christreld* or *islamredl* – and *femlabfpr* are also interesting: the correlation for *christreld* is positive and smaller than *islamredl* correlation, which has a negative signal. This is an indication that the Islamic religion is less supportive when it comes to women's agency, while the Christian religion promotes their empowerment. Finally, it is interesting to note that fossil fuel prices are all strongly and positively correlated, showing that when the price of one fuel increases, or decreases, the others will follow as they are interchangeable goods, and people tend to substitute their energy source when prices increase.

4.2 Regression Analysis

In Annex B, it is possible to see the first regression results for Fixed and Random Effects: tables B.1, B.2 and B.3 represent each of the homonymous model. Additionally, at the bottom of those tables, it is possible to see the results of the Hausman and Breusch-Pagan testing. The models correspond to the formulation presented in point 3.2.4, and were estimated in STATA.

By analyzing the Hausman Test results, it was possible to decide which of the estimators – Fixed Effects or Random Effects – was best suited for each of the models. Hausman Test results for Model 1and Model 2 indicate that under the current model specifications, the null hypothesis is rejected and therefore, the more adequate estimator is Fixed Effects, which remains consistent under correlation between unobserved individual heterogeneity (a_i) and the covariates. Model 3 presents opposite results, since in this case the null hypothesis is not rejected, indicating that the Random Effects estimator should be used as it is both consistent and efficient.

Next, for the three estimators the Breush-Pagan test was executed to assess the presence of Heteroscedasticity. Through the evaluation of the test results at the significance level of 1%, it was possible to reject the null hypothesis, highlighting that all models present Heteroscedasticity and therefore must be corrected. Given this result, the three models were re-estimated to include the correction of Heteroscedasticity through the STATA command robust command. The results can be observed in the table below. The table is divided in three sections: the first one exposes the coefficients of the explanatory variables, the second the coefficients of the control variables and the last section presents general indicators on the regressions.

Table 4.1.1: Estimation – final results

	Model 1 Fixed Effects	Model 2 Fixed Effects	Model 3 Random Effects
femlabfpr	0.012 (0.014)	-0.011 (0.037)	0.047 (0.276)
seatswomparl	-0.013*** (0.003)	-0.024 (0.018)	0.164 (0.106)
femempind	-0.725*** (0.244)	0.874 (1.410)	18.42** (9.275)
matmortr	0.000 (0.001)	-0.005 (0.003)	0.014 (0.016)
acccleanfuelp	-0.0014986 (0.004)	0.014 (0.010)	-0.10 (0.062)
islamreld	–	–	13.055 (11.029)
christreld	–	–	26.810*** (5.943)
gdppc	-0.000*** (0.000)	-0.000*** (0.000)	0.000*** (0.000)
fossilfuelresi	–	–	-10.574 (8.238)
oilprice	-0.002*** (0.001)	-0.000 (0.002)	-0.048*** (0.016)
coalprice	-0.000 (0.000)	0.001*** (0.002)	-0.044*** (0.012)
natgasprice	0.005 (0.005)	0.015 (0.031)	0.44*** (0.167)

europerd	–	–	-9.441 (18.475)
afrmerd	–	–	2.621 (24.045)
latamrd	–	–	22.971 (20.219)
southasrd	–	–	21.570 (21.121)
eastasrd	–	–	1.855 (19.260)
southeastsrd	–	–	-3.105 (20.900)
cons	2.198755 (0.475)	6.781 (0.194)	-1.202 (26.491)
Observations	1440	1440	1440
R-Squared			
RESET (p-value)	0.000	0.009	0.000

Note: *, **, *** denote statistical significance at 10%, 5% and 1% levels respectively. The dash (–) variable that were omitted due to collinearity.

The first model describes the relationship between the *enerint* and all the covariates. It was estimated following a fixed effects methodology. Four covariates – *femempind*, *seatswomparl*, *gdppc*, *oilprice* – were considered significant at 1%, with the coefficients matching the expected signal in table 3.2.4.1.

Of the significant covariates, two refer to the women's empowerment: *femempind* and *seatswomparl*. Despite having relatively small coefficients we may conclude that these aspects have a positive impact in decreasing the *enerint* – the amount of CO_2 equivalent emissions necessary to produce one unit of GDP – as when they increase, the *enerint* value will decrease. These results are in line with the ones found by Project Drawdown (2022), Regeneration (2023a), McGee *et al.* (2020) and Clancy and Feenstra (2019), which indicates that when women have more freedom of action and power of decision, they will make decisions with positive environmental impact. The two other covariates, *gdppc* and *oilprice* were also considered significant, however their coefficients are too low to be considered relevant in the calculation of the energy efficiency value.

The results of the second model – which has *co2pc* as its dependent variable – do not support the premise of this dissertation. Of all covariates, only two control variables are considered significant – the *gdppc* and the *coalprice* –, which present the opposite of the expected signal. One justification for these results may be the dual effect caused by female empowerment: on one hand, the increase of female empowerment is associated with a higher preoccupation and measures towards environmental aspects; on the other hand, countries with higher female empowerment are also the ones with higher levels of development and consequently, higher values of *co2pc*. These effects may offset each other in this dataset. Additionally, and based on the results found in Babir (2009), the unexpected signal could be justified by the fact that in the late 20th century, many manufacturing activities moved to developing countries, reducing developed countries' emissions.

The third model – studying the effects of an increase in female empowerment on renewable energy production – also produced important results. It has six significant variables at 1%, all with the expected signal: *femempind*, *gdppc*, *christreld*, *oilprice*, *natgasprice* and *coalprice*. The *femempind* appears to have a large effect on the renewable energy production, which is supported by Project Drawdown (2022), Regeneration (2023a), McGee et al. (2020) and Clancy and Feenstra (2019). This strengthens the hypothesis according to which, when female empowerment increases, the capacity for agency and decision on women's behalf also increases, and consequently the care for the environment becomes more of a priority. One important take away from this model is that all fossil fuel prices are relevant, reinforcing the need for renewable energy to showcase a competitive financial advantage against fossil fuels. Another interesting aspect of Model 3 is the positive impact of *christreld*. From maps 4.1.3 and 4.1.9, it is possible to see that countries with a higher level of renewable energy production are also Christian – such as European countries or Brazil – while countries associated to Islamism – as the Middle East region – tend to be more dependent on fossil fuels, and therefore more resistant to invest in renewable energy.

The models can also be analyzed as a whole, namely when it comes to it functional form. There are two main indicators: the value of the R-Squared and the value of the RESET test. The values of the R-Squared are exceptionally low for these models, which may be an indication that some important variables are missing. Regarding the RESET test, the results are very positive: for all three models the null hypothesis is not rejected, which is an indication that the models are formulated in a correct way and that the conditional mean is correctly specified.

5. Conclusions

The work developed in this dissertation aimed to assess the impact of female empowerment in the transition to sustainable energy system. Based on the Sociotechnical System theory defined by Geels (2004) and the Feminist Political Ecology theory of Rocheleau, Thomas-Slayter, and Wangari (1996), three econometric models were created and estimated. The goal was to understand if there is a relation – and if so, its type and magnitude –, between social changes related to women's empowerment and the technical changes associated with the transition to a sustainable energy system.

The econometric methodology provided some concrete results, offering answers to the initial research question and objectives, and shedding some light on the research topic. Models appear correctly specified, despite some important missing variables. This is an indication that this dissertation is on the right path. In terms of research results, it is possible to state that women's empowerment has a role to play when it comes to the transition to a sustainable energy system. This role is significant in both energy efficiency and energy transition, however, is more relevant when it comes to the adoption of "new" inventions – such as methods to increase efficiency or the adoption of renewable energy production. When it comes to reducing the amount of CO_2 equivalent emissions, the female empowerment indicators were not relevant.

A relevant note is that the common significant variable between the Model 1 and 3 is the *femempind*, which represents how the legal system portrays and protects women. This is an indication that when women see their power recognized in a society, and the more society protects their freedom, the higher their capacity to decide and act upon climate and societal issues. This corroborates previous findings and reinforces the need to guarantee and enhance women's freedom of choice and action.

Despite the successful answers to the proposed questions, this dissertation is not exempt of limitations. The main one arises from the difficulty in capturing correctly the effects of different variables on energy efficiency and transition. The movements for female empowerment can be studied separately, however they are dependent on other factors, namely the generalized country development, making it difficult to capture women's empowerment effect exclusively. Additionally, there are many aspects that also affect energy efficiency and transition such as legislation, societal practices or natural conditions, which may enhance or impair the evolution of these processes, and that were not possible to capture under this methodology. These factors can distort relationships present in the study, leading to inaccurate analysis. Finally, the scope of the study was also impacted by the lack of data in some world regions, namely Africa. More data would on developing and African countries would likely provide interesting results to analyze.

Nonetheless, there are various possibilities to extend this research. One of the possibilities is to analyze the impact of female empowerment on the transition to a sustainable energy system by grouping the countries by development level: this would allow a better perspective on the impact of development on these relations.

In the end, this projects emphasizes once more how important it is to keep studying and supporting the empowerment of women as its effects are deeper than it may seem on a first glance and likely hold the key to a true sustainable society. Additionally, this dissertation applied econometric methodologies that, despite not being a novelty, were rarely applied in these areas of study. In this sense, this dissertation fills a small gap in the literature and hopefully opens the door to similar and greater projects.

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Annex A: Classification of countries by world region and fossil fuel reference index

Country Name	Alpha 3 Country Code	Region	Oil price Index	Natural Gas Price Index	Coal price Index
Argentina	ARG	Latin America	WTI	Henry Hub	US Central Appalachian Coal Spot Price Index
Armenia	ARM	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Australia	AUS	Southeast Asia and Pacific	Brent	Henry Hub	Asia Marker Price
Austria	AUT	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Azerbaijan	AZE	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Barbados	BRB	Latin America	WTI	Henry Hub	US Central Appalachian Coal Spot Price Index
Belarus	BLR	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Belgium	BEL	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price

Bosnia and Herzegovina	BIH	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Brazil	BRA	Latin America	WTI	Henry Hub	US Central Appalachian Coal Spot Price Index
Bulgaria	BGR	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Canada	CAN	North America	WTI	Henry Hub	US Central Appalachian Coal Spot Price Index
Chile	CHL	Latin America	WTI	Henry Hub	US Central Appalachian Coal Spot Price Index
China	CHN	East Asia	Brent	Japan CIF	China Qinhuangdao Spot Price
Colombia	COL	Latin America	WTI	Henry Hub	US Central Appalachian Coal Spot Price Index
Costa Rica	CRI	Latin America	WTI	Henry Hub	US Central Appalachian Coal Spot Price Index
Croatia	HRV	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Cyprus	CYP	Europe	Brent	TTF (Between 2000 and 2004 it was used the	Northwest Europe Marker Price

				Average German Import Price)	
Czechia	CZE	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Denmark	DNK	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Ecuador	ECU	Latin America	WTI	Henry Hub	US Central Appalachian Coal Spot Price Index
Egypt	EGY	Africa and Middle East	Dubai/ Oman	Henry Hub	US Central Appalachian Coal Spot Price Index
Estonia	EST	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Finland	FIN	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
France	FRA	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Georgia	GEO	Europe	Brent	TTF (Between 2000 and 2004 it was used the	Northwest Europe Marker Price

				Average German Import Price)	
Germany	DEU	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Greece	GRC	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Hungary	HUN	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
India	IND	South Asia	Brent	Japan CIF	Asia Marker Price
Indonesia	IDN	Southeast Asia and Pacific	Brent	Japan CIF	Asia Marker Price
Ireland	IRL	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Israel	ISR	Europe	Dubai/ Oman	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Italy	ITA	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price

Japan	JPN	East Asia	Brent	Japan CIF	Japan Steam Coal Import CIF Price
Jordan	JOR	Africa and Middle East	Dubai/ Oman	Henry Hub	US Central Appalachian Coal Spot Price Index
Kazakhstan	KAZ	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Kenya	KEN	Africa and Middle East	Brent	Henry Hub	US Central Appalachian Coal Spot Price Index
Latvia	LVA	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Lithuania	LTU	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Luxembourg	LUX	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Malaysia	MYS	Southeast Asia and Pacific	Brent	Japan CIF	Asia Marker Price
Mexico	MEX	Latin America	WTI	Henry Hub	US Central Appalachian Coal Spot Price Index

Morocco	MAR	Africa and Middle East	Dubai/ Oman	Henry Hub	US Central Appalachian Coal Spot Price Index
Namibia	NAM	Africa and Middle East	Brent	Henry Hub	US Central Appalachian Coal Spot Price Index
Netherlands	NLD	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
New Zealand	NZL	Southeast Asia and Pacific	Brent	Japan CIF	Asia Marker Price
Norway	NOR	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Panama	PAN	Latin America	WTI	Henry Hub	US Central Appalachian Coal Spot Price Index
Peru	PER	Latin America	WTI	Henry Hub	US Central Appalachian Coal Spot Price Index
Philippines	PHL	Southeast Asia and Pacific	Brent	Japan CIF	Asia Marker Price
Poland	POL	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price

Portugal	PRT	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Romania	ROU	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Russia	RUS	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Saudi Arabia	SAU	Africa and Middle East	Dubai/ Oman	Henry Hub	US Central Appalachian Coal Spot Price Index
Singapore	SGP	Southeast Asia and Pacific	Brent	Japan CIF	Asia Marker Price
Slovakia	SVK	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Slovenia	SVN	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
South Africa	ZAF	Africa and Middle East	Brent	Henry Hub	US Central Appalachian Coal Spot Price Index
South Korea	KOR	East Asia	Brent	Japan CIF	Asia Marker Price

Spain	ESP	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Sri Lanka	LKA	South Asia	Brent	Japan CIF	Asia Marker Price
Sweden	SWE	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Switzerland	CHE	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
Tunisia	TUN	Africa and Middle East	Dubai/ Oman	Henry Hub	US Central Appalachian Coal Spot Price Index
Turkey	TUR	Africa and Middle East	Brent	Henry Hub	US Central Appalachian Coal Spot Price Index
Ukraine	UKR	Europe	Brent	TTF (Between 2000 and 2004 it was used the Average German Import Price)	Northwest Europe Marker Price
United Arab Emirates	ARE	Africa and Middle East	Dubai/ Oman	Henry Hub	US Central Appalachian Coal Spot Price Index
United Kingdom	GBR	Europe	Brent	NBP	Northwest Europe Marker Price

United States of America	USA	North America	WTI	Henry Hub	US Central Appalachian Coal Spot Price Index
Uruguay	URY	Latin America	WTI	Henry Hub	US Central Appalachian Coal Spot Price Index

Annex B: Estimation results without correction for Heteroscedasticity

Table B.1: Model 1 – Early results

	Model 1	
	Fixed Effects	**Random Effects**
femlabfpr	0.012***	-0.011***
	(0.003)	(0.003)
seatswomparl	-0.013***	-0.013***
	(0.002)	(0.002)
femempind	-0.725***	0.778***
	(0.103)	(0.101)
matmortr	0.000	-0.000
	(0.000)	(0.920)
acccleanfuelp	-0.001	0.001
	(0.001)	(0.001)
christreld	–	-0.446*
		(0.268)
islamreld	–	-0.851**
		(0.344)
gdppc	-0.000***	-0.000***
	(0.000)	(0.000)
fossilfuelresi	–	0.202
		(0.178)
oilprice	-0.002***	-0.002***
	(0.000)	(0.000)
coalprice	-0.000	0.000***
	(0.000)	(0.000)
natgasprice	0.005	0.005
	(0.004)	(0.000)
europerd	–	-0.615
		(0.389)
afrmerd	–	-0.838*

		(0.466)
latamrd	–	-1.190***
		(0.403)
southasrd	–	-2.225***
		(0.589)
eastasrd	–	-1.143**
		(0.539)
southeastsrd	–	-0.850*
		(0.438)
cons	2.198755	3.437
	(0.206)	(0.521)
Observations	1440	1440
R-squared	0.0188	0.2186
Breush-Pagan (*p-value*)	0.000	–
Hausman (*p-value*)	0.000	

Table B.2: Model 2 – Early results

	Model 2	
	Fixed Effects	**Random Effects**
femlabfpr	-0.011	-0.013
	(0.013)	(0.013)
seatswomparl	-0.024***	-0.024***
	(0.007)	(0.007)
femempind	0.874**	0.624
	(0.408)	(0.414)
matmortr	-0.005**	-0.006***
	(0.002)	(0.002)
acccleanfuelp	-0.014**	0.017***
	(0.005)	(0.005)
islamreld	–	-4.999**

		(2.300)
christreld	–	-3.326*
		(1.804)
gdppc	-0.000***	-0.000***
	(0.000)	(0.000)
fossilfuelresi	–	3.199**
		(1.193)
oilprice	-0.001	-0.002
	(0.002)	(0.002)
coalprice	-0.008***	0.007***
	(0.002)	(0.002)
natgasprice	0.015	0.016
	(0.016)	(0.017)
europerd	–	-8.787***
		(2.608)
afrmerd	–	-8.427**
		(3.083)
latamrd	–	-14.152***
		(2.696)
southasrd	–	-19.251***
		(3.893)
eastasrd	–	-11.334***
		(3.610)
southeastsrd	–	-9.052***
		(2.930)
cons	6.781	18.526
	(0.819)	(3.296)
Observations	1440	1440
R-squared	0.1205	0.2469
Breush-Pagan (*p-value*)	0.000	–
Hausman (*p-value*)	0.000	

Table B.3: Model 3 – Early results

	Model 3	
	Fixed Effects	**Random Effects**
femlabfpr	0.006	0.047
	(0.094)	(0.091)
seatswomparl	0.165***	0.164***
	(0.048)	(0.048)
femempind	17.996***	18.416***
	(2.953)	(2.925)
matmortr	0.01	0.014
	(0.012)	(0.012)
acccleanfuelp	-0.089**	-0.098**
	(0.036)	(0.036)
islamreld	–	13.055
		(16.353)
christreld	–	-26.810**
		(12.827)
gdppc	-0.000***	-0.000***
	(0.000)	(0.000)
fossilfuelresi	–	-10.574
		(8.846)
oilprice	-0.048***	-0.048
	(0.013)	(0.013)
coalprice	-0.045***	-0.044***
	(0.013)	(0.013)
natgasprice	0.431***	0.435
	(0.118)	(0.118)
europerd	–	-9.441
		(18.548)
afrmerd	–	2.621

		(21.936)
latamrd	–	22.971
		(19.173)
southasrd	–	21.570
		(27.684)
eastasrd	–	1.855
		(25.674)
southeastsrd	–	-3.105
		(20.835)
cons	17.138	-1.202
	(5.929)	(23.429)
Observations	1440	1440
R-squared	0.072	0.358
Breush-Pagan (*p-value*)	–	0.000
Hausman (*p-value*)	0.6431	