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Climate Change in Coastal Zones: A Case Study of Coastal Tourism Activities in Coastal Region on Italy's Mediterranean Zone.

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Forward

Tourism is known to be a major source of economic gain for some regions including Venice, where I study, in Italy. Before the start of my thesis, I worked with a restaurant and an estate manager involved in managing rooms and apartments for tourist accommodation in the Lido di Venizia and Lido di Jeselo respectively during the heat of the 2022 summer period (July 2022 to October 2023). As a housekeeper in the tourist accommodation, we were asked to also keep the air conditioning on the day of the arrival of the guest, to keep the room/apartment comfortable for the tourist. Also, as a staff in the restaurants, the same approach was also taken to keep the restaurant comfortable for tourists even if there is no customer. This operation observed in both the tourist accommodation and restaurants spiked my curiosity to investigate what extent temperature increase affects the tourism operator, and they are making gains or experiencing losses in this era of temperature increase.

Dedication

This thesis is dedicated to my parents Mr. Uba Martine Ebere and Mrs. Uba Juliet Chinwe, and my siblings, for their financial support to see that I arrive here in Ca' Foscari University of Venice for my studies.

Acknowledgement

Having reached the end of this fruitful training in environmental science, I will not fail to give gratitude firstly to Professor Carlo Carraro, my thesis supervisor and teacher, who inspired me throughout the period he taught me in the subject, Environmental Economics and Finance. His status in academics motivated me to always work hard during his class and throughout this thesis. Also, my gratitude goes to Professor Francesco Bosselo, for always creating time for his inspiring interaction regarding the progress of this thesis, which contributed to the success of the research methodologies. Also, Dr Robert Onyeneke from Nigeria was there for me to clarify my doubt regarding my methodologies. Thanks to my fiancé, Elisa Sarto, who also encourages me to keep on pressing hard even when I get tired.

Abstract

The study reveals the impact of temperature increase on the demand, supply, and investment in the tourism activities in coastal zones of Italy both at the national Level (Italy) and at the regional level – Abruzzo, Liguria, Calibria, Campania, Sicilia, and Sardegna were selected coastal regions and Valle d' Aosta for control (non-coastal) region. Observations were made from 1999 to 2019 for the regional level and 2008 to 2019 for the national level, and data were analyzed using a statistical analytical software (R programming). Regression models, and time series plot and correlogram were used for statistical analysis and visualization of trends and relationships, while the Climate Change Risk Adaptation Assessment (CCRAA) Framework for Infrastructure developed by the State of Queensland (Department of Transport and Main Roads) 2020 were used for the risk assessment. Result revealed that temperature increase has both positive and negative effect, and direct and indirect impact on tourism demand and supply in coastal zones at the regional and national level. It also has some economic consequences which include damage and prolonged operational time of cooling system in hospitality (accommodation and restaurant sectors). There was no clear definition on how temperature increase affects specific tourism businesses at the regional level but there was defined evidence on how temperature increase affects tourism demand, supply, and investment at the national level, and with a combined effect of temperature and tourism demand on tourism supply. The relationship between temperature increase, tourism demand, and supply is strong at the national level but weak at the regional level. The risk and vulnerability level in the tourism supply in the coastal regions requires immediate institutional intervention and adaptation measures need adequate and proactive measures.

Content **pages**

List of Tables **pages**

List of Figures **pages**

List of Appendices **pages**

1.0 Introduction

Climate change poses a severe threat on low-lying coastal areas with sea level rise (Susmita et al, 2022; Mohamed et al, 2021; Aysha et al, 2021). Natural forcing and anthropogenic activities especially emission of greenhouse gases and changes in land use pattern in recent decades have been the dominant cause of the changing global climate, which results to increase in sea surface temperature, sea level rise, large variability in rainfall pattern and intensity of storm (Mageswaren et al, 2021). Therefore, climate change is now a global affair because of its growing concern of its widespread significant socio-economic impact especially on the welfare of developing and under developing countries. However, climate change results to several socio-economic challenges in the coastal zones (Md. Jahid et al, 2021), including its consequences on key sectors such as travel and tourism, ranging from destruction of historical valuable tourist sites to losses in economy and tourist infrastructure (Amadu and Adongo, 2022). Climate change has different manifestations at regional levels, and these observed changes are mainly in atmospheric circulation. Several studies reveal that the warming of the troposphere leads to a change in the extent of the Hadley cell, and its northern boundary moves northward in the northern hemisphere, especially in boreal summer and autumn (Nojarov, 2021).

1.1 Climate Change in Coastal Zones

The ocean, which accounts for 11% of the earth's surface area, has absorbed approximately 93% of the extra heat generated due to the greenhouse effect. This effect has significantly caused the warming up of the global ocean leading to the rising of global mean sea level (GMSL). Since the 21st century, GMSL has consistently risen and extreme events, such as strong typhoon (hurricane), storm surge, extremely high temperature, marine heatwaves, and heavy rain, have distinctly increase, which pose a threat on coastal zones and its socio-economic activities (Cai et al, 2021).

Coastal Zones is a transition area between land (continent) and sea, and it signifies a relatively small area with extremely productive and diverse ecosystems (Mageswaren et al, 2021; Quadrado and Goulart, 2020; Lo Presti et al, 2022; Akrivi et al, 2021). Coastal zones are very economic zones (Mageswaren et al, 2021; Akrivi et al, 2021), and are considered one of the environmental systems that are particularly exposed to current and projected risks connected to climate change. It consists about 2% of the total land area around the world and about 10% of the world's population live on it within 10m elevation of sea level, are identified to be at particular risk to climate change impacts, according to the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report (AR5) on coastal systems (Stewart and James, 2021; Yi et al, 2022), given their logistic, recreational, and cultural potential, and the availability of resources (Quadrado and Goulart, 2020; Staudt et al, 2021). Where about 2.2 billion people, 29% of the world's population live in flood-prone areas that vary in the level of inundation. Sea-level rise increase will lead to intrusion of saltwater to land, coastal erosion and aggravate the effect of coastal storms. These areas including Small Island Developing Countries (SIDC) are sensitive to sea-level rise, increase inundation level and amount to precipitation, increase sea surface temperature, accelerate coastal erosion, and saltwater intrusion, which leads to significant socio-economic effects such as population displacement, loss of properties, the recession of economic and industrial activities, loss of coastal habitats and loss of tourism, reduced recreational activities and transportation function (Mohamed et al, 2020; Arsum et al, 2021; Aysha et al, 2021; Mageswaren et al, 2021).

About 25% to 30% of the global GDP is derived from the coastal region. Almost 1.3% of the global population are vulnerable in the event of a 1-to-100-year flood. This exposure can lead to considerable damage, amounting to 10% of the global gross domestic product by the end of the century if proper adaptation measures are not adopted in the early stages. Acknowledging the risk and vulnerability associated with sea-level rise, impact assessment and adaptation strategies need to be worked out from the local level. However, sea level rise will not be uniform geographically and will vary across regions due to the influence of melting glaciers, wind system and other localized processes that affect the local sea levels. These local and regional levels might show marked differences from the mean global sea-level (Aysha et al, 2021).

In a changing climate, variations in the number, path and strength of atmospheric cyclonic storms may modify the development of storm surges. The amplitude and impact at a given location depends on the intensity, size and speed of the storm, coastline orientation and local topo bathymetric characteristic. Moreover, hazards and disasters associated with this unusual rise in sea level are highly correlated with storm frequency and characteristics. Various coastal flooding usually occurs when wind-induced waves and storm surges coincide with high tides, which are responsible for extensive coastal erosion. Their impact can be more destructive on densely urbanized coasts, resulting in human and economic losses. Storm surges refer to an abnormal rise in sea level caused by low atmospheric pressure and the force exerted on the sea surface by strong winds. It is measured as the height of the water above normal predicted astronomical tides. An important aspect of coastal storms that differentiates them from other extreme events is their genetic process, which is driven by atmospheric disturbances over the open ocean which generates storm surges. However, the impact of sea level rise and consequently, storm surges, which are potentially strong.

Flood accounted for 44% of all disasters recorded globally in the last two decades with India ranked second after China in terms of flood with an average of 17 $years^{-1}$ and over 345 million people affected (Manasl et al 2022). In recent years, wind wave over the global ocean basin have experienced significant changes, indicating a clear increase in extremes over the North Indian Ocean Basin. The annual mean height has increased at a rate of 0.27cm/year, and the frequency of tropical cyclones over Arabian Sea showed an increasing trend. Study reveals around 600% increase in Tropical Cyclones intensity over the Bay of Bengal basin during the past decades. Also, several case studies have revealed increased coastal vulnerability due to storm surges, extreme wind wave and sea level rise (Bishnupriya et al, 2021).

According to the Forth National Assessment Report on Climate Change, initiated by the Chinese government in 2017, to assess the impact of climate change on the China Coastal Zones and sea and associated risks and adaptation countermeasures, the sea-level rise at China's Coast also raises the water level of storm surges, which can easily cause serious flood disasters in coastal areas, particularly during the period of astronomical tides and heavy precipitation. It has reported in October 1999 that the combined effects of strong onshore winds, heavy precipitation, huge wave, huge astronomical tides, and rapid currents is reported to damage the 1160m long embankment in Xiamen City and the coastal blocks were flooded. Over 700 people were killed and injured. In October 2013, a strong Typhoon hit Fujian and Zhejiang provinces, affecting 1216 million people, and estimated 63.14 billion RMB economic losses. Seventy percent of the Yuyao City, Zhejang Province was flooded and waterlogged for several days with 830,000 people affected by the disaster. Since the 21 century, Marine Heat Waves (MHWs) in global ocean and China's offshore have increased from 2016 to 2018, the sea surface temperature (SST) and temperature in China's coastal areas reached to the highest recorded values, which causes great economic losses of 6.87 billion RMB in the coastal areas. It has been revealed from various studies that the intensity of strong hurricanes and Typhoon have increased recently under the global warming era and become frequent, posing a major threat to several region globally. Under different climate scenarios, the global climate is expected to be warming and sea level will continuously increase in the future. This situation may lead to frequent exposure of coastal areas to strong typhoons and storm surges and may further threaten the safety of infrastructure, transportation, and tourism. This projection shows that global sea level and China's coastal area will significantly rise in the future, and the return period of extreme water level in many coastal areas will be shortened notably. About 150 to 250 million people in the global coastal areas will be below the coastal high tide by 2050 (Cai et al, 2021).

Coastal erosion is an effect of the redistribution of sand which occurs in seasonal cycles along many parts, or long-term losses of sand offshore, along shore or inland (Gilmour and Ellison, 2021). The combination of sea level rise, an increase in frequency and intensity of extreme events, such as heavy precipitation, and the limitation of sediment sources or lateral transfer budget-river or updrift beaches which are cut off through dams or coastal structure, leads to the erosion of sandy beaches in many areas. Especially, urban areas lack natural and dynamic dry land behind the beaches-dunes system or coastal forest, which might serve as buffer enhancing coastal protection levels. The inland movement of eroding beaches and coastal ecosystem is often limited by coastal development, causing coastal squeeze. This coastal squeeze intensifies the effect of erosion and subsequently risks integrity of both ecosystem and infrastructure (Staudt et al, 2021).

1.2 Climate Change in the Mediterranean Coast

The Mediterranean region is considered the world's leading tourism destination which attracts one-fifth of international tourism arrivals worldwide, and one of the most vulnerable areas to climate change because of its unique natural attributes and the huge topographic, climatic, and geographic variability (Enriquez and Bujosa Bestard, 2020). It is one of the world's leading tourist destinations, receiving about 30% of international arrivals in 2015 and 41% of the European arrivals in 2019. It is also an area of interest for studies on tourism in terms of climate change impact due to its ecosystem changes such as sea level rise, ocean warming and acidification (Akrivi et al, 2021). It is composed of a highly contrasting topography; the combination of land and island complexes with beautiful and ruffled coastal configuration; the 46,000km of coastline, enrich with fantastic land and seascapes and wealthy marine sites; the abundant terrestrial and marine biodiversity and so on. Due to its natural diversity, cultural diversity, and wealth of the Mediterranean, it was an attraction of eastern and western civilization and their interactions through centuries, which has promoted some of the world's first and greatest civilization, thereby establishing it the cradle of Europe's civilization as well as the place that encourages the Renaissance Era. Great thinkers and artists such as Aristotle, Plato, Cicero, Socrates, Leonardo da Vinci, Michelangelo, and Galileo originate from the Mediterranean region, while it is the home of all the seven wonders of the world. The cultural, linguistic, and socio-economic diversity, and the exceptional commercial transactions developed through the ancient sea routes, transformed the Mediterranean region into a prominent place for habitation and economic activities; and a significant place of attraction for travelers of classical time, who were aspiring to explore and experience the cultural peculiarity of the region. The key driving force of its wealth remains the sea and the coastal part of its land, with Mediterranean Coastal Communities being the most flourishing, prosperous, and predominant places, and a home to large part of population over the centuries. Therefore, the Mediterranean region is presently experiencing serious demographic, social, cultural, economic, and environmental changes, especially in the coastal zones and marine resources, influenced by climate change, considering that warming trends are moving 20% faster, compared to the global average, sea level rise, inundation, and flooding (Akrivi et al, 2021).

According to the Intergovernmental Panel on Climate Change (IPCC) prediction, the Western Mediterranean region will experience advances of aridity and high temperature soon. The forest will persist as human activity intensifies in the region (Lopez-Belzunce et al, 2022). Recent studies revealed that the Mediterranean Sea has been identified as a climate change hotspot for the coming decades. The significant trends, mostly increasing, have been observed in several Mediterranean regions for several parameters, including air temperature, precipitation, sea surface temperature, sea level rise, wind speed, wave surge and significant wave height (SWH) (Amarouche et al, 2022). Caillaud et al (2021) in their study revealed that the Northwestern Mediterranean is affected by Heavy precipitation events during the fall season, with rainfall amount greater than 100mm recorded in less than a day within a few hours leading to destructive flash flooding and floods, creating severe occurrences.

Lo Presti et al (2022) in their study carried out in North-Eastern Sicily (Southwestern Mediterranean), using a flooding map, revealed a projected coastline for 2050 and 2100, with an average retreat of 6m along the pebbly-sandy beaches, and a maximum of about 10m in the beach sector facing the town of Gioiosa Marea. The hypothesis of the occurrence of large and extreme storms at 2100, when sea level will be high than today, suggests that different effects will occur than those currently observed on the coast. This effect will involve internal coastal areas, causing great damage to the anthropic structures. Also, in a study, Amarouche et al (2022), on new wind-wave climate record in the Western Mediterranean Sea, it reveals that most of the Western Mediterranean Sea experience (within 41 years) a significant increasing trend in Significant Wave Height (SHW) and mean annual Wind Speed (WS). Compared to the seasonal means, the trend is also positive for winter, spring, and autumn, but for the summer season, the trend is significantly negative in the East and West Coasts of the basin. Also, trend results of the annual average monthly SWH_Max show larger area with significant increasing trends, mainly in European region. Since 2013, about half of the West Mediterranean Coast have registered records in wave climate, not recorded at least since 1979, and several regions. This finding may support a hypothesis regarding a probable link between climate and the recent extreme wing and wave events. The most affected areas by wind and wave climate variabilities, defined based on a spatial assessment of new wave records and the trend analysis results according to Amarouche et al (2022), are mainly Catalan Coasts and Eastern Sardinian Coast, Genava Coaste and Monaco Coast, having recorded three successive SWH records since 2013. Also, the West Coast of Golf de Lyon where a new record was reported in 2013, and a significant increasing trend with 99% confidence level was also noted for WS and SWH, for all seasons and with a considerable annual increase in slope estimated between 1979 and 2019. Overall European and Africa Coast in the Mediterranean Sea are experiencing a worrying risk related to the wind and wave climate that requires serious mobilization for the prevention of probable catastrophic wave storm events and to ensure sustainable and economic development.

1.3 Climate Change in Beaches and Urban in Coastal Zones

Climate change impact in coastal zones such as increased erosion and inundation, are commonly attributed to the effect of mean sea level rise, with an increasing focus on how Extreme Sea Levels (ESLs) will change in the future. ESLs can be defined according to their probability of occurrence or their impact, with both approaches giving unique insights into the spatial and temporal scales of event. Studies have revealed that the height of ESls, could increase further than that which will occur due to Global Mean Sea Level (GMSL) rise in some locations. The contributing factors of coastal impact are storms, astronomical tides, and wave condition (Leach et al. 2021), which are primary factors of beach recession.

Sandy beaches in the world are at risk from sea level rise and related erosion processes arising from global climate change, consequently leading to reduction in the beach area. However, the changes will not be similar across all coastal zones in the world (Zajch et al, 2022). Sandy beaches are coastal environments that change in time and space corresponding to the depositional morphology and the hydrodynamic behavior of the region in which they are located. The slope given rise by hydrodynamic process causes modifications in beach morphology, at the same time as acting hydrodynamic is altered accordingly to the changes induced by morphology. Given the dynamic of coastal processes, sediments are constantly being moved (Quadrado and Goulart, 2020).

During high energy condition, Waves can speedily erode and remove sand from beaches, foredunes and hind dunes during high energy conditions and 70% of beaches have retreated because of coastal recession influenced by climate change. The sandy shores which are backed by low terrain are some of the most vulnerable areas to erosion and inundation, caused by relative sea-level rise and severe storms (Gilmour and Ellison, 2021). Quadraudo and Goulart (2020), also in their study on sandy beaches in Southern Brazil, revealed that the rates of sediment transport demonstrate a variation in daily meteoceanographic conditions, especially in wave and wind components. Wave parameters, median grains, and beach slope were seen to strongly influence longshore sediment transport. The result from the study Zajch et al (2022), suggest that the impact of sea level rise will have a greater effect on beach tourism resources than changes in climate suitability. Based on the projected changes, the magnitude of beach loss (>50%) shows the severity of beach loss. The large ensemble range (~35 – 65%) emphasizes the sensitivity of beach loss estimates and the need for more localized projections.

Also, climate change has demonstrated the five warmest years on record occurring since 2015 and the 2010 to 2019 decades, being the hottest ever observed. Increased incidence of extreme heat, prolonged heat wave all may generate severe effect on tourism, tourist behavior and as well as tourist operators (Dundas and von Haefan, 2021). Regional climate change could influence the climate of the urban connected to the beach through the presence of higher ambient temperature than other distant surroundings. The phenomenon is known as Urban Heat Island (UHI) and consists of the most documented phenomenon of climate change. Intensification of global climate change and an increase in the amplitude and frequency of heatwave is found to strengthen the magnitude of the overheating in cities mainly because of the significant synergies between the two phenomena. Higher urban temperature has serious impact on the energy consumption of buildings, peak electricity demand, the efficiency of the power plants, and indoor and outdoor thermal comfort levels, while it affects the survivability of low-income tourist operators. Analysis of a high number of relevant studies has shown that the heat island phenomenon induces as increase of the peak electricity demand close to 21 (±10.4) watt per person and the degree of temperature increase, while the cooling energy penalty is found to be close to 0.7kwh/m^2 of city surface and degree of temperature increase (Ansar et al, 2022). According to the IPCC (2022)[1] 6th Assessment Report on climate change impact on energy consumption, peak load may increase more than energy consumption, and the changing spatial and temporal load patterns can impact transmission and needs for storage, demands – side management, and peak generating capacity (*high confidence*). It also reported significant net impacts with the commercial and industrial sector and substantial air condition penetration, driven an increase energy demand, and 7 to 17%increase in energy consumption due to climate change in 2050, establishing that peak energy demand during heatwave can coincide with higher temperature (Hyun-Gyu, 2021).

1.4 Climate Change in Coastal Tourism Activities

Climate change is at the lead of challenges facing the tourism industry from global to local level (Day et al, 2021; Zajch et al, 2022). Changes in climate patterns can therefore create opportunities and/or threats for tourism activities in concerned regions (Berred and Berred, 2021), and will affect the wellbeing of tourists and their decisions (Amininia et al, 2020). Tourism is one of the world’s largest and fastest growing industries. It accounts for 10.40% of the global Gross Domestic Product (GDP), and according to the World Travel and Tourism Council (WTTC), its direct contribution to the GDP is expected to grow at an average of 3.8% per year over the next 10 years. It is considered a highly climate sensitive economic sector. Most tourism products and services depend on the environment which is affected by changing climate (Amadu and Adongo, 2022), in fact, climate change is likely to have significant impacts on tourism destinations and operators, and varies by geographic region (Enriquez and Bujosa Bestard, 2020; Beeharry et al, 2021; Day et al, 2021). The impact will be direct or indirect ways ranging from rising temperature and sea levels, destruction in natural attraction coral bleaching and reef damage, to changes in demand. More importantly, at the receiving end of the adverse effect of climate change on tourism are the individuals whose livelihoods depend on the travel and tourism sector (Amadu and Adongo, 2022).

Coastal tourism is considered as one of the quickest growing areas. It has recently been predicted that international arrivals are expected to boom annually by 4.3% to reach 1.8 million by 2030 and coastal areas remain attractive tourist destination for millions of visitors who prefer to take advantage of sea air, sun, water, sea food, beaches, and scenic views. The decision to travel to a destination is influenced by several factors, whereas an important one includes recreational tourism activities. Tourism activities here refers to “any endeavor such as experience, game, sport and hubby undertaken beyond someone’s usual environment for a particular duration and that the principal motive behind travelling is not to generate any income from the place visited”. Key coastal recreational activities consumed by tourists at their destination include snorkeling, cruising, and fishing among others. Residents at a destination also use products and services catering to visitors, including outdoor and indoor recreational activities (Beeharry et al, 2021; Day et al, 2021).

According to Nojarov (2021), the Northern boundary of the North Atlantic European region is associated with the Azores height, which also affects the western part of the Black Sea. These changes affect the direction and velocity of the wind and the waves in the studies area of the Black Sea. During the active tourism season in Bulgaria, between June and September, the wave of the sea is essential for swimming in the sea, suitable for safety of the tourist. The high sea along the Bulgarian beaches leads to a ban on entry into the sea by the authorized agencies, which discourages tourist and as a result, reduces tourist activities. Risk of drowning and death because of violation of beach regulations can negatively affect the status of the tourist destination. In this instance, the wave of the sea and temperature is one of the main factors determining the development of tourism in an area.

Unseasonal warm or cool temperature can lead to dissatisfaction with the destination (Day et al, 2021). The sun and the beach were the most popular reasons given (42%) for going on holiday in Eurobarometer Preferences of Europeans towards tourism published in March 2016. The weather determines tourist comfort, and the best schedule for many activities which can be done during the holidays are those related to nature, city trips or sports and operational costs. Therefore, in this 21st century, the tourism industry is considered highly vulnerable to climate change, even more than the overall challenges to tourism, and it constitutes a threat to the tourism-dependent economies of many small islands, in the Caribbean, and Mediterranean Sea, and the Indian and Pacific Ocean (Carrilo et al, 2022).

Arsum et al (2021), in a study on the impact of climate change on the tourism sect of a Small Island Developing State in Bahamas, revealed that tourism sector on the island of NP and PI in Bahamas is threatened by sea level rise and storm surge. Six properties (11%) are located within 1m sea level rise and face the risk of inundation. Thirty-four percent (34%) of the coastal tourism businesses on the islands of NP and PI are currently located in Cat 1 storm surge zone and more than 83% are in a Cat 5 storm surge zone. With the future projected increase in sea level rise, the exposure from the storm can significantly increase to as much as 90% of the properties vulnerable if a Cat 5 storm makes landfall on these two islands. Even in a conservative scenario of Cat 1 storm surge, up to 51% of the properties will be vulnerable with a 1m sea level rise.

In 2016, when Hurricane Matthew hit the South Coast of New Providence Island with a storm surge height of more than 2m, it resulted to damages estimated to USD 600 million in the Bahamas. Tourism-related infrastructure such as Nassan Airport and surrounding roads were flooded or damaged. It has been predicted by researchers that there will be an increase in the frequency of such severe category (Cat) 4 and 5 storm like Matthew and more recent Dorian in the 21st century, which is the most recent and prominent example of extreme events and their impacts on the wider socio-economic and environmental conditions of the Bahamas. Pacific Small Island Developing States (SIDS) that rely on tourism have also been severely impacted during the south pacific cyclone season, of which a recent example is Cyclone Gita, a Cat 4, in 2018, that made landfall in Tango, causing widespread infrastructural damages. Many SIDS are dependent on single economic sectors such as tourism that provide the main source of employment and economic growth. Tourism created one 7 in four new jobs in the Caribbean region and contributed 20% of the total visitor exports in 2019. The tourism sector generated USD 3678 million, accounting for 81.6% of the Bahamas visitor exports. The hotels and restaurants are a significant area of interest for foreign direct investment in the Caribbean SIDS. A well-managed tourism sector can provide opportunities for the growth of other sectors such as fisheries and transportation (Arsum et al, 2021).

1.5 Economic Impact of Climate Change in Coastal Tourism Operators

Sea level rise is one of the dominant threats of coastal tourism which has drawn attention for assessment, and it is notable for its cost in climate change. (Bigano et al, 2008). According to the study Bigano et al (2008), direct costs of sea level rise were lower than impacts on GDP when terms of trade improve and vice versa. Adding that the different degrees of ability in substituting the land lost with other production factors and capital outflows driven by reduced rate of returns re-rank countries in terms of experienced losses. This implies that, climate change impacts on developing countries are more severe, because of the dependence on a vulnerable sector, but, more directly, to the magnitude of the negative shocks imposed substantial effects on prices than on quantities, as a comparison of real and nominal GDP changes. They further reported that the effect interaction does play a role when considering combined impacts. If other associated shocks are imposed, factor and good substitution possibility in the economic system are increasingly constrained or expanded. Thus, adjustments to each of the single shocks caused by the combination of the joint disturbances became more costly than they would be if only one shock were considered at a time. In economic terms, changes in tourism flow caused by climate change affect the demand scale, and demand decomposition affects the tourism market service (Bigano et al, 2008; Grimm et al. 2018).

1.5.1 Impact on Supply and Demand

The supply-side of tourism is composed of the major resources that attracts tourists to a destination which the suppliers of the goods and services that enable the delivery of products to consumers (tourists) from their home to and including all aspects of the destinations. The supply chain of tourism involves many sub sectors which include accommodation, transport and excursions, bars and restaurants, handicrafts and other retail shopping and food production, as well as the infrastructure water supply, access routes, waste management, cooling, and heating systems, that supports tourism. Tourism operators have a significant influence on the supply chain and can promote enhanced sustainability performance which is a factor of business management and continuity through business-to-business relationship (Golden Associates, 2012). Warmer summer can indirectly enhance local economies through sales of weather-related products which protect against ultraviolet rays, and to reduce heat impact (Grimm et al, 2018).

The demand-side of tourism is made up of the needs and motivations that drive individuals to become tourists and these drivers include availability of disposable income, the motivation and ability to travel, as well as other emerging factors, that is, destination preference, quality expectation and booking behavior. These factors are constantly evolving as personal choices, as new destinations and new products with competitive prices compete with established tourism offering (Golden Associates, 2012). Climate change can affect tourism demand directly by interfering with the choice of destination and the holiday stay period or affecting the quality of the experience based on adverse perception after some extreme event and insecurity about the destination (Grimm et al, 2018). It has been proven that damages on infrastructure caused by climate change possess a negative impact on the esthetics of the tourism destination, especially for tourists who are fresh to the tourist destination (Kaarina, 2019).

Climate change generate important effects on the tourism industry, since both supply and demand of tourism services depends upon the quality and the management of a set of environmental attributes which are under threat of modification by climate change (Kaarina, 2019; European Central bank, 2021). The supply side of tourism has limited investigations on the economic impact of climate change, while focus is concentrated on the demand side of tourism which includes the variations of tourist inflow and their expenditure. There are no reports on how climate change impacts affect the image of the tourism destination as they are good indicators to predict the tourist destination choices, satisfaction, and decisions in expenditure. (Arabadzhyan et al, 2021).

1.5.2 Impact on Cashflow and Budgeting

Climate change impacts on small and medium sized enterprises have recently received attention in the global agenda. Prediction in 2015 suggested that climate change would cost private businesses between USD 4.2 trillion and USD 43 trillion between then and the end of the century. Most small and micro businesses lack access to capital and resources and operate with marginal profits and therefore have limited cash reserves to respond to and recover from a disaster. They also tend to be housed in non-engineered buildings and often have insufficient capacity to devise and execute a disaster management plan (Chanrith et al, 2020). This impact could produce both supply-side shocks resulting to price volatility, and demand-side shocks including reduced disposable income, and business investments negatively impacted by uncertainty and financial losses following climate disaster (European Central Bank, 2021; Mercer, February 8, 2022).

Results from Chanrith et al (2020) reported that impacts experienced by business owners because of climate change include decline in the number of clients, cutting-off of production chains (particularly businesses relying on agricultural and natural resources products), loss of profits, products and shop damage, and disruption in business growth. There is observed direct impact of climate change on cashflow, which is problematic in terms of budgeting. Eva et al (2015) indicated that the cost occurred through an increase in maintenance cost and energy consumption. If these are not well budgeted beforehand, the cost may result in cashflow problems among small businesses, which typically have less financial reserve for unexpected expenses. Moreover, the monetary costs that were reported in the study only include tangible costs that can be traced to bookkeeping.

1.5.3 Impact on Employment

There is generally a high awareness of the influence of climate change on tourism operators' employment as most of the stakeholders acknowledged how climate change has already and or may further continue to affect their employment. According to Fatoric et al (2017), age is likely to play a factor in risk perception as stakeholders who were over 41 years old, were more likely to express stronger perceptions of the impact of climate change on their employment than their younger counterparts. This is related to the fact that tourist employment, which is largely seasonal, tends to be concentrated in the younger segment of the population (March et al, 2014). Increasing coastal erosion and sea level rise might adversely affect tourism industry through reduction in the esthetic appeal, surface areas of beaches, damage to infrastructure and causing it as less attractive tourism destination and second home residence. Though some stakeholders perceived benefits from climate change, stating how it can facilitate jobs and other economic opportunities (Fatoric et al, 2017).

Study from Mycoo and Gobin (2013) reported that during the turtle nesting season, 92 persons (29% of the total population of Grande Riviere) were employed by the resort and guesthouses which accommodated turtle watching visitors. The resorts also generated revenue for their owners. But in contrast, Eva et al (2015) reported observed failed recruitment (example, too many seasonal workers, too early in the season) which was a contributing factor to the increased loss of revenue.

1.5.4 Impact on Electricity Consumption/Cost

Climate variability, tourism arrivals and electricity consumption are interconnected by many potential sources, as climate determines tourism destination choices, and tourism requires more electricity consumption. Though this may differ from place to place.

A study, Pablo-Romero et al (2019) reported that tourist overnight stays in the Spanish Mediterranean Provinces increases, which has also affected the electricity consumption in the hospitality sector because of the need to open new establishments as tourism demand increases. This is connected to the fact which indicate that an increase in temperature produce a greater demand for cooling energy, and a decrease in temperature produces a greater energy demand for heating in the hospitality sector, and therefore, more electricity used in the sector. This is in line with the study Hyun-Gyn (2021) who reported that with an assumption of 2^{o}C average temperature increase, the electricity consumption of residential and commercial sectors is projected to increase by 6% and 8% respectively between the month of July and August in the summer season, and with an average temperature increase of 2^{o}C and 5^{o}C, total electricity consumption in August would increase by 4.1% (1.5TWh) and 11.3% (4.1TWh) respectively, creating an additional costs of 0.17billion dollars and 0.45 billion dollars assuming the average marginal cost of electricity is 11 cents per KWh.

Pablo-Romero, et al (2017)[1] reported that the hospitality sector electricity consumption elasticity with respect to GDP per capita is positive, which translates the increase in GDP per capita increases the hospitality sector electricity consumption. This study supports the relationship between hospitality sector electricity consumption and overnight stay, which means as tourist overnight stay increases, the electricity consumption in the hospitality sector increases. Also, in a related research Pablo-Romero et al (2017)[2], result revealed that temperature coefficient was positive and significant, thus, lower temperature tend to increase electricity consumption, especially for heating, in the hotel and restaurants. In this regard, the changing of the temperature through this period is significant in affecting electricity use.

1.5.5 Impact on Adaptation/Investment Cost

Adaptation in tourism studies refers to the action to reduce the negative effect of climate change and to benefit from the positive effect. This concept is focused on how a unit aims to adapt to change through transforming its operation and is usually observed as a local scale response. Therefore, adaptation and related actions should provide to climate resilient development to improves the systems (climate) stress tolerance and the ability to reorganize or continue operation in changing environment. Adaptation generates costs which may in certain cases hinder or even prevent action, and it aims to create benefits for the unit transforming its activities to manage operations and survive events arising from changing climate. In other words, adaptation is an investment where the exact net benefits are difficult to measure. The tourism sector is a sector where small enterprises dominate the field, and consequently the costs of any extracurricular activity may turn into an insurmountable obstacle. Nevertheless, assessment of the source and the costs emanating from the consequences of change is very significant (Kaarina et al, 2018). While the tourism sector consists of several stakeholders being affected by the changing climate and play different role in adapting the tourism sector into the changing climate, the role of tourism operators is given prominence to the concept of adaptation and mitigation. (Kaarina, 2019).

According to, Eva et al (2015) and Kaarina (2019), most of the adaptation cost occurred in the accommodation and food sector (restaurants and bars), which typically have high infrastructure investment. In this regard, the tourism operators with large investment, especially in the built environment, suffer from having less adaptation capacity and flexibility to climate change as their operational environment is more fixed, but the recreation and program services suffer from additional costs because of they are more exposed to and dependent on changing environment and weather elements, and consequently experience bankruptcy because of reduced access to financial markets and especially if the operational area has a high degree of competition which is the case of coastal areas (Kaarina, 2019).

Mycoo and Gobin (2013), who studied the leatherback turtles and beach loss in coastal management, climate change adaptation and sustainability in small coastal community revealed that leatherback turtle nesting has generated economic activity because of the large number of visitors that travel annually to the remote coastal village of Grande Riviere for turtle watching. Visitation records confirm that as many as 15,000 visitors per annum come to view the laying and hatching of leatherback turtles. This finding is substantiated by previous research who estimated that 10,000 persons visited Grande Riviere in 2006 for this purpose. Consequently, turtle nesting has influenced small-scale investment in accommodation for visitors. Five small resorts now exist compared with the two that were established between 1993 and 2000. And 12 guesthouses currently provide 150 rooms.

Upscale and foreign-owned hotels appear to have invested heavily into significant adaptation projects, such as seawalls, as well as building features targeted at mitigating the negative effects of increasing rainfall, storms, and increased temperature. It is also worth notifying that the most pervasive adaptation measure utilized across the board is the increased use of air conditioning, which is a reactionary strategy that may create unintended knock-on effects further down the line, unless electricity is produced from renewable source (Tinat et al, 2021).

1.5.6 Cost and Benefit of Adaptation/Investment Cost

There is an increasing involvement of governance, focused on businesses and their perception, preferences and decision making in climate change. Government represents a new form of public management structure along market (or quasi-market) organizational models, where governing structure focus on incorporating a range of interest drawn from the private sector, rather than focusing on primarily on the traditional roles of public sector government, they are increasingly. Thus, in market and private sector operators on a local scale, decision making and responsibilities in adaptation are also developed, with a strong emphasis on decentralizing adaptation to the lowest level of governance where the need to understand how businesses operate and perceive potential, or existing cost and benefit of climate change are highlighted, following the application of a quantitative approach for the cost and benefit of climate change in tourism operators (Kaarina et al, 2018).

Kaarina et al, (2018), evaluated the cost and benefit of environmental change and potential adaptation measures in businesses operating in tourism destinations in two artic communities in Finish Lapland. The benefit through changing consumption patterns and increasing sales while costs were directed towards a quite specific part of business operations (example, certain element of infrastructure, work force and salary cost). Forty-four percent of the respondents stated to have experienced weather-related costs and the numerical responses specified that the average cost of adaptation was 5.1%. On the other hand, the experienced benefits affected 78% of the entrepreneurs resulting in an average of 7.3% increase in turnover. Socio-economic changes associated with infrastructure, economic issues, sales, and customer-base, were discovered to affect tourism development by 88% of the interviews. In respect to adaptation, result reviews more tendencies for passive adaptation, where the decision are made based on experience and occurred changes. Eighty-eight percent of the interviews experienced changes in their natural environment, with sentiments varying between negative and positive impacts. Also, the experienced changes and the following benefits that were felt by 78% of the respondents emphasize passive adaptation. Understanding emerging climate conditions shows an element of active adaptation, despite the importance of passive adaptation. Though the costs are mostly related to passive adaptation, there is an occasional active adaptation investment present. The accommodation and restaurant sector seems to be benefiting the most from the changes in weather fluctuation, but small-scale businesses and recreational programs are assessed to suffer the most, whereas transport and other sector are only benefiting as they did not report any cost. The combination of enterprises also seems to mainly benefit. Certain phenomena may mean high costs for some sectors while others seem to benefit from their occurrence, reducing the destination-wide costs.

1.6 Climate Change Mitigation and Adaptation Policy on Coastal Tourism

Climate is a key asset to tourism destinations and some tourist destinations and countries will benefit positively from the changing climate but will negatively impact consumers demand for others. Mitigation policy impact travel and tourism positively and negatively at both regional, national, and international level. For instance, mitigation strategies such as carbon taxes, by increase in travel costs, may reduce demand for travel. Some researchers speculate that travel may become less socially acceptable as climate change impacts increase (Day et al, 2021).

The high exposure level of tourism sector to climate change effect cannot be denied. Climate projections into the future are intended to assist in the design of adaptation measures, as the climate conditions for tourism will improve in winter and intermediate seasons, above all in high altitude, but will worsen in summer, mainly because of the deterioration of thermal comfort, which makes it obvious that tourist destinations will need to adapt to climate change (Carrilo et al, 2022). Potential impact of climate change to tourism can be reduced with high adaptive capacity, and it is important to identify priorities for adaptation to ensure tourism resources are maintained and managed effectively (Zajch et al, 2022).

Enriquez and Bujoisa Bestard (2020) revealed that tourist visiting the Sun- and Beach destination of Mallorca in Spain support the implementation of adaptation policies aimed at counteracting the three-climate induced environmental change evaluated: beach retreat caused by sea level rise as well as the loss of posidinia oceanica meadows and the increase in jellyfish outbreaks, which are correlated to sea water warming, which is consistent with previous studies. Their study also provide evidence of preference heterogeneity among individuals with different socioeconomic and travel characteristics, corresponding to other studies: while older and higher educated individuals are more concerned with climate change impacts and show stronger support for the adoption of adaptation measures, tourist visiting the destination for its provision of accommodation infrastructure will not be so concerned about climate-induced environmental changes in coastal areas and hence will show weaker support for climate change adaptation. Estimated result from the study also show that beach retreat will have the worst marginal impact on Sun-and-beach tourists (1.23 euros), followed by beach closure due to jellyfish outbreaks (0.90 euros) and the loss of posidonia oceanica meadows (0.31 euros), which also is consistent with similar analysis performed outside the tourism industry.

1.7 Coastal Resilience for Tourism Operators

Slowing down the impact of climate change and reversing the climate crises requires strong public and political will for climate action and support for climate action is strongly influenced by climate belief and concern. Public perception and acceptability of climate change are essential in mobilization of the needed public support for climate policy and other mitigation effects (Amadu and Adongo, 2022). With both policy management and practice, increasing moving towards maximizing some form of resilience, achieving coastal resilience to climate change is now recognized as a desirable outcome. Coastal resilience is the capacity of the socioeconomic and natural system in the coastal environment to cope with disturbances, induced by factors such as sea level rise, heat wave, storm surge, flooding, extreme events, by adapting whilst maintaining their essential factor (Stewart and James, 2021).

The adaptive response of entities within the tourist system varies widely and can be considered using level of analysis: the macro-level analysis considers destination communities; the meso-level analysis aims at individual businesses, while the micro-level analysis investigates individual behavior, including organization behavior and individual’s traveler behavior. Tourism is dependent on infrastructure such as transportation, water, and energy, and the various factors by which tourism operators’ response to climate change include understanding the potential impacts which include paying close attention to weather changes in a daily responsibility, and adaptation tends to be operational, adjusting part-time/seasonal workers schedule, adjusting facilities to accommodate weather changes such as rain or heat. Impact of changing weather, including heat, will impact workers and visitors, and operators will need to adjust accordingly. Changes in operational cost like energy consumption and cost, with increasing cooling needs in summer and decreasing heating needs in winter will cause responses like financial hedging using weather derivatives which may significantly reduce cash flow volatility, which is applicable to small tourism operators that lack information on financing options and access to funds for adaptation coast (Day et al, 2021). Also, general public support will alleviate near-term suffering for poor tourist operators in coastal zones, but may increase the likelihood of tragic losses in long-term which include encouragement of poor tourist operators to remain and invest in high-hazard areas that will ultimately become untenable as climate change continue, and draining resources away from other development objectives by inevitably-rising compensation, thereby threatening poverty alleviation in businesses in non-coastal areas. Eventually, the tension on public resources may prove insupportable, leading to sudden discontinuation of compensation for many payments dependent tourist operators in the coastal zones, rapid impoverishment, and forced relocation (Susmita et al, 2022).

With the recent evidence of sea level rise acceleration, tourist operators in low-lying coastal areas will need to plan for potential impacts from progressive inundation, heightened storm damage, increased heat wave, which will significantly vary by location along the coastline both in time-phasing and magnitude, creating differential pressure for on-site adaptation and/or relocation. The increase in climate impact presents policy makers with decisions like firstly, to conserve public resources by leaving adaptation to the affected tourist operators. In this non-intervention policy, tourist relocation occurs as operators respond to perceived threats, bearing the displacement cost themselves. This policy ensures relocation by default as coastal conditions deteriorate, but at the cost of potentially severe inequality among operators differentiated by location only. Secondly, to respond to immediate equity concerns by compensating operators for climate-related damage. But this policy will encourage operators to stay put if operators are fully compensated, until emergency intervenes through ocean encroachment and potentially deadly storm surges. Thirdly, to provide positive incentive through successive classification risk zone as ocean encroachment progresses, with compensation focused on operators willing to relocate. Each policy involves benefits and costs from a public welfare approach, and each may be applicable in some circumstances. Effective public management requires detailed knowledge of the affected operators, the ability to predict future reactions as climate change proceeds, and implementation of cost-effective adaptation policies. Policy makes need clear evidence from actual country experience to appropriately draw conclusion (Susmita et al, 2022).

Recently, several actions have been implemented in China's coastal areas to address climate change, and various adaptation measures have been adopted which help to reduce the impact of extreme climate disasters. Nevertheless, there still exist great uncertainties in occurrence and impacts of future ocean warming, sea level rise, and extreme weather disasters, which result in the corresponding difficulties and risks in decision making with challenges of considering the cost, benefits and trade-offs of adaptation, countermeasures, such as land-use planning, infrastructure investment, strengthening seaward coastal engineering protection, or taking the initiative to relocate and evacuate landward can be implemented to deal with the impacts of sea level rise and extreme events. Also, timely adjustment in relevant decisions and adaptation measures by fully considering the risk tolerance and uncertainty of stakeholders. Decisions and adaptation measures with higher risk tolerance may adopt a smaller uncertainty range – the possible variation range of potential impact and intensity of disaster risk. However, those with lower risk tolerance must consider a larger uncertainty range (Cai et al, 2021). Parrado et al (2020) revealed that higher losses are mainly because of the use of extreme sea level rise related to a 1-to-10,000-year flood which implies higher impact and adaptation cost, the recursive dynamic setting that amplifies effects on growth compared to static exercise, and the inclusion of public borrowing effect that crowd's savings out and therefore investments with a further negative impact on growth. This is more evident in the no additional adaptation – high sea level rise scenarios were government face larger deficits because of lower tax revenue or increased current expenditures, and then they must borrow from private households to finance the deficit which ends up increasing public dept as well as the dept burden. On the contrary. In the additional adaptation scenarios, even though the government is borrowing to finance adaptation investment and maintenance costs, the benefits are higher than the burden of the adaptation dept, since with adaptation, government have either higher tax revenue or lower current expenditure (Parrado et al, 2020).

1.8 Identification of Gaps in Climate Impact on Tourism Activities

Notwithstanding the economic importance of the sector and its corresponding vulnerability to climate change, the study of climate induced impacts has not received sufficient attention, and considerable knowledge gap remains. Several studies on climate change on tourism revels that the focus of recent papers is on the direct consequences of climate change that is, the variation in climatic suitability of tourism destination specifically. The papers on climate as a resource for tourism builds on studies that seek to identify comfortable conditions for tourists by means of different climate indices such as awareness, satisfaction, or destination choice or to develop demand models to estimate potential shifts in tourism flows or visitation patterns because of climate change (Enriquez and Bujosa Bestard, 2020; Carrilo et al, 2022). According to Dat et al (2021), different travel and changing destinations have possibilities, but how climate change will impact market is uncertain and difficult to predict. Also, there are insufficient research assessing the long-term effect of climate change and climate policies on investment in tourism from several aspects of tourism operators and its welfare impact of tourists measured in terms of their Willingness to Pay (WTP) (Enriquez and Bujosa Bestard, 2020). Economic assessment of the variation in consumption of power for cooling resulting from climate change are not available now (Spano et al, 2022). The application and success of adaptation are large uncertainties that require more assessment and consideration (Leal et al, 2022). Finally, the combined cost and benefit methodology has not been widely implemented to tourism research, with most existing tourism studies focusing on the cost element alone (Kaarina et al, 2018).

Notwithstanding, attempts will be made to solve these gaps through an econometric and expert judgement approach. Therefore, this research thesis will focus on the social economic impact of climate change on tourism operators in the coastal region of Italy by:

1. Assess the relationship between climate variability, tourism demand and supply variables in the coastal region of Italy.
2. Carry out risk and vulnerability assessment on the impact of climate change on tourism demand and supply in the coastal region of Italy.

2.0 Climate Change in Coastal Zone and Tourism: Italy Perspective

Almost all the alluvial coastal plains in Italy, which include those on the Tyrrhenain and Adriatic Coast, are characterized by subsidence that locally causes severe modification in Relative Sea Level (RSL) trends (Di Paola et al, 2021). The coast of Italy is surrounded by the Mediterranean and Adriatic, and with a total length of over 9,000km, the coastline of Italy is exceptionally geographically diverse as well as both historically and economically valuable for the country. Notable features along the coastline include sandy beaches which are of interest in this study (Spano et al, 2022). These attributes make Italy one of the top destinations of the world for both tourism and business motivation (Vincenzo, 2020).

The economy of Italy has gained directly and indirectly from tourism, with GDP of 13.0% accounted for and workforce of 14.7% employed in 2017. It employed 2.0 million people directly in 2018, accounting for 8.3% of employment in the tourism industry and it was estimated that 216,000 businesses were operating in the accommodation sector in 2018. Data for 2018 arrivals show an increase in trend which corresponds to the global trend. According to accommodation statistics, the number of inbound visitors totaled 63.2 million up from 60.5 million which explains growth of 4.4%. international overnight stays rose by 33.2% between 2011 and 2018. Almost 60% of international arrivals head to just four regions – Veneto, Lombardy, Lazio, and Tuscany. A total of 62.9 million domestic overnight trips were made in 2018 (OECD, 2020).

2.1 Sea Level Rise, Storm Surge and Flooding

Observations on sea level rise for Italy was estimated at 1.64mm per year since 1903, with the North Adriatic area identified as one of the most susceptible to sea level rise. Recent report from IPCC projection establishes that, by 2050, global sea level may rise between 0.18m and 0.23m under the low emission scenario and high emission scenario respectively. On average, one in 100 extreme sea level events expected to rise from 1.12m at present day to 1.3m by 2050 under the medium emission scenario. The coastline is also home to a significant proportion of the population. Coastal erosion and temporary inundation because of storms are recurrent along the coast of Italy, in particularly in areas with low lying beaches. With several areas in the Italian coast being exposed to the impact of inundation and storm, such as North Adriatic Sea and the Venetian Lagoon, the country has begun to feel the impact of the sea level rise. The low lying and subsiding Po Delta and other several regions of the Italian coast are vulnerable to the effect of storm surges and extreme waves. The Mediterranean Sea sees relatively small tides and low energy storms as it continues to observe an increasing number of extreme events, which are causing concerns because of fears of erosion and other damages, particularly given an increasing coastal population. A projected increase in the frequency and intensity of extreme waves and storms could worsen the coastal impact of climate change significantly, especially when considered in combination with sea level rise, which will increase the probability of such events as well as compounding their severity. Although it is possible that storms may not increase in severity in a significant way, expected sea level rise is likely to lead to more severe impacts. Approximately 4500km^2 of coastal areas in Italy are at risk of flooding due to sea level rise over the next century; the area's most at risk are situated in the Northern Adriatic Sea, the Po Delta, and the Venice Lagoon, where there are highly urbanized areas, cultural heritage sites and industrial establishments situated below sea level (Spano et al, 2022).

Di Paola et al (2021) revealed that in the next decades in Campania - Italy, beaches, human infrastructures, and touristic areas can be affected by marine inundation and related impacts, and the observed subsidence trends play a consistent role in increasing sea level rise impact along the investigated coastal stretches, especially in Volturno coastal plain, where current subsidence rates range from -1 to -25mm/year and the H_4 class reaches its maximum extent, and the Northern sector of the Sele coastal plain. Result from Anzidei et al (2021), revealed the contribution of sea level rise to the shoreline retreat at a level lower than 35% in Southeastern Sicily (Italy). A variable shoreline changes in the coastal plain of Catania were established between 6.34 and 3.23mm/year (with a linear regression of 4.78 ±2mm/year). There is an observed drastic retreat in shoreline up to 10m/year in Simeto, Gurnazza and San Leonardo River mouths. The southern part of the coastal plain influences large subsidence, reaching a rate up to 8 ±2.46mm/year in the Lentini area. The mobile coastal system exhibits a phase of decrease of sediment supply, particularly over the last decades. The reduction of suspended load from Simeto, Gurnazza and San Leonardo determined a negative sedimentary balance, which is exacerbated by the intense beach-dune erosion. The sandy coast of Siracusa shows a rate of shoreline changes between 4.01 and 3.9mm/year (linear regression rate of 4 ±1.9mm/year). This occurred south of Ciane River mouth, and the coast of Vendicari demonstrated a rate of shoreline retreat between 0.95 and 0.4mm/year, with a mean rate of 0.68 ±0.4mm/year. The foredune system showed stability over the last four decades, while the dynamic of the coast seems to be correlated to the longshore drift towards south with the largest flooding which is expected in the coastal plain of Catania and the Lentini area. Concerning the role of the dune system in counteracting the SLR, field evidence and optical satellite images show that over the last two decades, the beach-dune systems have been subjected to a continuous retreat. The beach-dune system will be more vulnerable in the next years with respect to the past decades.

2.2 Heatwaves

Heatwaves (HWs) are extended periods of unusually high atmosphere-related heat stress, most of which had high thermal index value over 35°C. They have significant indirect effects, such as increased energy consumption due to the intensified use of air-conditioning, which further exacerbates heat accumulation. For example, during the first week of a HW in Spain in July 2015, electricity consumption increased 8% compared to normal consumption for that period. HWs episodes are especially intensified in cities due to urban street canyons, excessive heat accumulation caused by construction materials, a lack of vegetation and green space, and/or a lack of open spaces that facilitates the release of waste heat from air-conditioning and other energy uses. This micro-climatic effect can be intensified during hot summer, and exposure to high temperature can lead to heat stress which can increase the demand for energy and water usage. Coastal cities in Italy are also vulnerable to impact from heatwaves and flooding, following intense precipitation events. Heatwaves are increasingly frequent and especially night-time temperatures. Frequency, intensity, and duration of heatwave will be significantly higher for urban areas in the coastal zones. Energy poverty rate in the coastal zone of Italy is higher because low-income tourism operators, including other businesses and homes, don't always have the means to keep their business building and homes cool in summer and warm in winter. With the future climate scenario, this problem is expected to intensify. In more recent years, increasing summer peak demand for air-conditioning by tourism operators in the hospitality/accommodation and restaurants, has caused stress to the energy system at the local level. Stronger increases in cooling need are expected in the densely populated coastal regions of Italy. Also, moderate decrease in heating need is expected in the southern coast of Italy. The current trend of rising summer temperature, with rising chances of heatwave is expected to intensify, leading to peak electricity demand due to the Urban Heat Island (UHI) effect in the coastal urban areas (Spano et al, 2022; Joan et al, 2021; Leal Filho, 2022).

Vincenza (2020) analyzed the electricity consumption in the Italian tourism sector during the period of 1995 to 2017. The study revealed that electricity consumption between 2017 and 1995 showed an increase of 38%, namely 4.243GWh. There was a change in the number and typology of hospitality structure which caused an increase of 3.680GWh of electricity consumption. Also, an increase in electricity intensity contributed to the rise of the consumption, resulting to 1.901GWh. This change is linked to the observed increase in services based on electrical energy offered by the tourism sector. One main contributor is the introduction of air-conditioning, which is a major infrastructure in hospitality structures.

2.3 Projected Economic Impact on Italy's Coastal Zone

In Europe, severe economic impact is expected in Italy because of its highest exposure to flood risk. In a scenario of 3°C temperature increase by 2070, the direct cost would fall between 1 and 2.3 billion Euros per year in the period 2021 to 2050 in terms of expected loss of infrastructure capital, and between 1, 5 and 15.2 billion Euros per year in the period 2070 to 2100. It has also been revealed that the damage from flood events in the RCP 8.5 scenario will fall between 4.5 and 11 billion Euros in 2050 and between 14 and 72 billion Euros in 2080. There is also high expectation of cost attributed to sea level rise and coastal flooding. Recent study by the CCMC projected losses for 2050 between 650 million Euros in RCP 4.5 and 900million Euros in RCP 8.5. Also, there will be rise in losses to 3.1 billion Euros in RCP 4.5 and 5.7 billion Euros in RCP 8.5 in 2100.

The coastal areas of Italy located in the Mediterranean hot spot for temperature, is particularly vulnerable to changing climate conditions. Gross Domestic Product (GDP) losses related to climate change impact can be significant already by mid-2050 under a low emission scenario. Losses could double by the end of 2100 under a high emission scenario. With respect to sea level rise damages, assuming that no new investments in coastal protection are undertaken, the expected annual damages on assets under a high emission scenario may peak at 81 billion Euros already in 2050. By 2100, annual damages can range between 18.4 and 213 billion Euros depending on different assumptions on adaptation. For river flooding damages, increased frequency and intensity of extreme weather events can generate applicable economic losses associated with riverine flooding. 9.6 billion Euros in expected annual damages to infrastructure assets could be experienced under a high emission scenario in the second half of the century. For example, the historic city of Venice, which is already facing significant impact from sea level rise and storm surge, threatening many points of cultural heritage. Also, beaches for tourism recreation experience chronic beach erosion. In 2019, it contributed 10.4% of national GDP. It can also be one of the sectors most severely impacted by climate change (Spano et al, 2020). Also, this will affect the rate of employment in the tourism sector.

2.3.1 Projected Economic Impact on Italy's Tourism Sector

A simple variation of the thermal comfort conditions associated with future temperature has also been observed. This will possibly cause variations in the flow of tourists. In a scenario with 2^{o}C increase in temperature, a 15% reduction in international arrivals is estimated, and 21.6% in a 4^{o}C increase scenario. The net impact on total Italian demand results in a contraction of 6.6% and 8.9% with direct losses for the tourism sector, which is estimated at 17 and 52 billion Euros in the two climate scenarios, respectively.

The loss of climate attractiveness of Italy's tourism destinations, becoming too hot, can induce the increase of cooling degree as an adaptive measure by tourist operators in the hospitality sector. The National Climate Change Adaptation Plan for Italy reports a conspicuous increase in cooling degree days, events which the average daily temperature exceeds 24^{o}C, both in the RCP 4.5 and RCP 8.5 scenario, and a reduction in heating degree days, events in which the average daily temperature drops below 15^{o}C. therefore, in respect to the lower efficiency and higher cost of converting energy demand into final energy consumption, which characterizes cooling technologies compared to heating ones, the increase in costs for the cooling will outweigh the savings relative to the heating. This will create more problematic management of flow of energy in Italy (Spano et al, 2022).

Therefore, the rest of this research thesis is organized as follows; Chapter 3 describes the case study areas for tourist destination characterized with coastal beaches and urban. Following is chapter 4, which describes the methodology – the proposed models, stating their relevance and the approaches on how they will be used to address the problems. Chapter 5 shows the results deriving from the model analysis, and risk and vulnerability assessment. Chapter 6 illustrates the discussion and conclusion.

3.0 Case Study Areas

Six region which include four coastal regions (Liguria, Campania, Calabria, and Abruzzo), and two Island (Sicily and Sardinia) were carefully selected based on the presence of tourism activities and availability of sufficient timeseries data. Two non-coastal regions (Valle d' Aosta and Lombardy) were also selected as a control region with the same criteria.

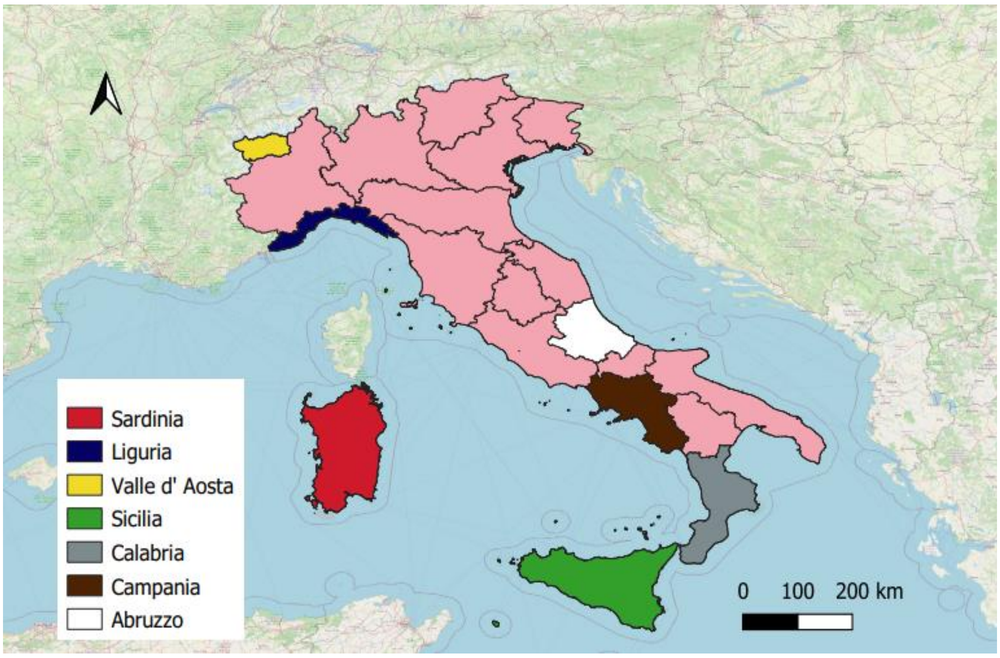

Figure 1.0: Map of Italy showing the six coastal regions and the two non-coastal regions.

3.1 Liguria and its Climatic Conditions.

Liguria is one of the smallest regions in Italy with a surface area of 2,092 square miles (5,418 square Km) and a population of 1, 557, 533 as at 2017. It lies within the coast of Ligurian Sea in the northwestern part of Italy. The region is crossed east to west by the Ligurian Alps and the Ligurian Apennines that form an interrupted chain but discontinuous in its morphology, which consists of 3,524.08Km^2 of mountains and 891.95Km^2 of hills. The hills lying immediately beyond the coast together with the sea account for a mid-climate year-round. Average winter temperatures are 7 to 10^{o}C and summer temperatures are 23 to 24^{o}C, which make for a pleasant stay even in the dead of winter. Rainfall can be abundant at times, as mountains very close to the coast create an orographic effect. Genon and la Spezia can see up to 2000mm of rain in a year. Other areas instead show the normal Mediterranean rainfall of 500 to 800 mm annually. The presence of mountains which offered it a shelter from winter wind makes the climate attractive for tourism activities in the numerous coastal resorts (https://en.wikipedia.org/wiki/Liguria https://www.britanica.com/place/Liguria).

3.2 Campania and its Climatic Conditions

Campania is a region that lies along the coast of Tyrrhenia Sea, between the Garigliano river (North) and the Gulf of Policastro (South), with a surface area of 5,249 square miles (13,595 square Km) and a population of 5,869,029 as at 2014. It contains mostly mountainous areas of which 34% of the total area is mountainous, 51% is hilly, and the remaining 15% is made up of plains. There is a high risk of seismic risk across the region. The mountainous interior is fragmented into several massifs, rarely reaching 2,000 meters, whereas close to the coast there are volcanic massifs: Vesuvio and Campi Flegrei. The climate is typically Mediterranean along the coast with warm, sunny, and sultry summers and mild, rainy winters, whereas in the inner zones, it is more continental with lower temperature in winter and warm summer. Snow is possible at higher elevations but rare at sea level. The several industrial activities and it flourishing artisan industry attracts tourist trade in the province of Naples, on the Sorrento Peninsula, and on the Island of Capri and Ischa, which contribute greatly to its economy (https://en.wikipedia.org/wiki/Campania https://www.britanica.com/place/Campania).

3.3 Calabria and its Climatic Conditions

Calabria is a region southern Italy with an area of 5,823 square miles (15,080 square Km) and a population of 1,877,527 as at 2021. It is a peninsula of irregular shape stretching out in a northeast-southwest direction and separating the Tyrrhanian and Ionian Seas. Most of the region is mountainous. Its climate is influenced by the sea and mountains. The Mediterranean climate is typical of the coastal area with considerable difference in temperature and rainfall between the season, with an average low temperature of 8^{o}C during the winter month and an average high temperature of 30^{o}C during the summer month. Mountain areas have a typical mountainous climate with frequent snow during winter. The erratic behavior of the Tyrrhenian Sea can bring heavy rainfall on the western slope of the region, while hot air from Africa makes the east coast of Calabria dry and warm. The mountains that run along the region also influence the climate and temperature of the region. The east coast is much warmer and has wider temperature ranges than the west coast. The geography of the region causes more rain to fall along the west coast than that of the east coast, which occurs mainly during winter and autumn and less during the summer months. The government of Italy also promoted the development of tourism in suitable spot along the coast (https://en.wikipedia.org/wiki/Calabria https://www.britanica.com/place/Calabria).

3.4 Abruzzo and its Climatic Conditions

Abruzzo is a region located along the coast of the Adriatic Sea with a surface area of 4,168 square miles (10,794 square Km) and a population of 1,305,770 as at 2021. Most of the region is mountainous. There are two climate zones in Abruzzo. The coastal strip and sub-Apennine hills have a climate markedly different from that of the mountain interior. Coastal areas have a Mediterranean climate with hot dry summers and mild winters. Inland hilly areas have a sublittoral climate with temperature decreasing progressively with increasing altitude. Precipitation is also strongly affected by the presence of the Apennines

Mountain range. Rainfall is abundant on slopes oriented to the west, and lower in east and east-facing slopes. The Adriatic coast is shielded from rainfall by the barrier effect created by the Apennines. The minimum annual rainfall is found in some inland valleys, sheltered by mountain ranges, such as Peligna or Tirino (Ofena, Capestrano) where little as 500mm was recorded. Rainfall along the coast almost never falls below 600mm. Pescara has relatively less rainfall than Chieti. The highest rainfall occurs in upland areas on the border with Lazio: they are especially vulnerable to Atlantic disturbances. About 1500 to 2000mm of precipitation is typical. There is increasing tourism activities in the coastal resorts which is of economic importance to the region (https://en.wikipedia.org/wiki/Abruzzo https://www.britanica.com/place/Abruzzo).

3.5 Sicily and its Climatic Conditions

Sicily is the largest Island, southern Italy. It has an area of 9,830 square miles (25,460 square Km). It is one of the most densely populated islands in the Mediterranean Sea with a population of 4,969,147 as of 2019. It lies about 100 miles (160km) northern Tunisia (Northern Africa). The Island is separated from the mainland by the strait of Messina (2 miles [3Km] wide in the north and 10 miles [16Km] wide in the south). Sicily has a typical Mediterranean climate with mild and wet winters and hot, dry summers with very changeable intermediate seasons. On the coasts, especially in the south-west, the climate is affected by the African currents and summers can be scorching. Snow falls above 900–1000 m, but it can fall in the hills. The interior mountains, especially Nebrodi, Madonie, and Etna, enjoy a full mountain climate, with heavy snowfalls during winter. The summit of Mount Etna is usually snow-capped from October to May. On the other hand, especially in the summer, it is not unusual that there is the sirocco, the wind from the Sahara. Rainfall is scarce, and water proves deficient in some provinces where a water crisis can happen occasionally. A report by the Regional Agency for Waste and Water, the weather station of Catenanuova (EN) recorded a maximum temperature of 48.5 °C. Total precipitation is highly variable, generally increasing with elevation. In general, the southern and southeast coast receive the least rainfall (less than 50 cm (20 in)), and the northern and northeastern highlands the most (over 100 cm (39 in)). It's sunny, dry climate, scenery, cuisine, history, and architecture attracts many tourists from mainland Italy and abroad. It hosts the UNESCO World Heritage Sites, Tentative Sites, Archeological Sites, Castle and Castle towers (https://en.wikipedia.org/wiki/Sicily https://www.britanica.com/place/Sicily).

3.6 Sardinia and its Climatic Conditions

Sardinia region is the second largest Island in Italy in the western Mediterranean with a surface area of 9,300 square miles (24,090 square Km) and a population of1,622,257 as of 2019. It lies 120 miles (200Km) west of the mainland of Italy, 7.5 miles (12Km) south of the neighboring French Island of Corsica, and 120 miles (200Km) North of the coast of Africa. The climate of the island is variable from area to area, due to several factors including the extension in latitude and the elevation. It can be classified in two different macro bioclimates (Mediterranean pluviseasonal oceanic and Temperate oceanic), one macro bioclimatic variant (Sub Mediterranean), and four classes of continentality (from weak semi-hyperoceanic to weak semi continental), eight thermotypic horizons (from lower thermos-mediterranean to upper supratemperate), and seven ombrotypic horizons (from lower dry to lower hyperhumid), resulting in a combination of 43 different isobioclimates. During the year there is a major concentration of rainfall in the winter and autumn, some heavy showers in the spring and snowfalls in the highlands. The average temperature is between 11 to 17 °C, with mild winters and warm summers on the coasts (9 to 11 °C in January 23 to 26 °C in July), and cold winters and cool summers on the mountains (−2 to 4 °C in January, 16 to 20 °C in July). Rainfall has a Mediterranean distribution all over the island, with almost totally rainless summers and wet autumns, winters, and springs. However, in summer, the rare rainfalls can be characterized by short but severe thunderstorms, which can cause flash floods. The climate is also

heavily influenced by the vicinity of the Gulf of Genoa (barometric low) and the relative proximity of the Atlantic Ocean. Low pressures in autumn can generate the formation of the so-called *Medicanes*, extratropical cyclones which affect the Mediterranean basin. In 2013, the island was hit by several cyclones, included the Cyclone Cleopatra, which dumped 450 mm of rainfall within an hour and a half. Sardinia being relatively large and hilly, weather is not uniform; the East is drier, but paradoxically it suffers the worst rainstorms: in autumn 2009, it rained more than 200 mm in a single day in Siniscola, and 19 November 2013, locations in Sardinia were reported to have received more than 431 mm within two hours. The western coast has a higher distribution of rainfall even for modest elevations. The driest part of the island is the coast of Cagliari gulf, with less than 450 mm per year, the minimum is at Capo Carbonara at the extreme south-east of the island 381 mm (15.0 in), and the wettest is the top of the Gennargentu mountain with almost 1,500 mm per year. The average for the entire island is about 800 mm per year, which is more than enough for the needs of the population and vegetation. The Mistral from the northwest is the dominant wind on and off throughout the year, though it is most prevalent in winter and spring. It can blow quite strongly, but it is usually dry and cool. Tourism is essentially concentrated on the coast because of its Architecture, Art and World Heritage Sites (https://en.wikipedia.org/wiki/Sardinia
https://www.britanica.com/place/Sardinia).

3.7 Valle d' Aosta and its Climateic Conditions

Valle d' Aosta and *Lombardy* are two non-coastal regions, bordering Switzerland in the northern part of Italy, with surface areas of 1,259 square miles (3,262 square Km) and 9,211 square miles (23,857 square Km), and with populations of 122,953 in 2022 and 10,103,967 in 2019 respectively. Both regions' economies are based on tertiary sectors, on tourism. Due to the orography of the Valle d'Aosta area, there are very different local microclimates even between nearby valleys or slopes. Temperatures vary according to the altitude of the territory. At high altitude there is an alpine climate, so summers are short and alternate with long cold winters with temperatures that drop even to -20 ° C and with peaks even below -30 ° C at altitudes greater than 2,000 m. Continental climates are observed in the valley floors: in winter temperatures drop below 0 ° C; in summer, on the other hand, they rise even over 30 ° C, with poor ventilation that accentuates the feeling of sultry. The rain on the Aosta Valley is scarce, especially when compared with the other regions of the Alpine sector, as the winds that blow most frequently are from the west and discharge their moisture content on the western slopes of the Alps. The inner valleys embedded between imposing reliefs are very dry. Their richness in culture, art, museums and architectural sites makes them attractive to tourists' trade (https://en.wikipedia.org/wiki/Valle d' Aosta https://www.britanica.com/place/Valle d' Aosta).

4.0 Methodology

4.1 Data Collection

To achieve the objective of this study and to attempt to close the research gaps secondary data are sourced to investigate the climate change impact on both the supply side and demand side of tourism operators at a regional and national level. Secondary data are sourced from relevant institutions to assess the relationship between climate change and tourism demand and supply. For climate change, it is important to recall that temperature is one of the main determining factors in the development of tourism. It determines the tourists' comfort, and the best schedule for many activities which can be done during the holidays, and because of this, unseasonal warm or cool temperature can lead to dissatisfaction with the destination (Day et al, 2021; Nojarov, 2021). Therefore, at regional level, temperature data for the years 1999 to 2019 for each of the selected case study regions and 2008 to 2019 for Italy at national level is used as a climate variable in this study and sourced from the NASA POWER-Data Access Viewer (https://power.larc.nasa.gov/data-access-viewer). For the demand side of tourism at regional level, numeric data for number of nights spent at tourist accommodation establishment in Hotels; Holiday and Other Short-stay accommodation; Camping ground, recreational vehicle parks and Trailer parks (NSTA) for the years 1999 to 2019 for each of the selected case study regions, is sourced from Eurostat. Also at the regional level, selected data for social and economic variables for the years 1999 to 2019 for each of the selected case study regions, which describes the supply side of tourism operators are also sourced from Eurostat. They include: (a) Number establishments in Hotels; Holiday and Other Short-stay accommodation; Camping ground, recreational vehicle parks and Trailer parks (NE). (b) Number of bed places in Hotels; Holiday and Other Short-stay accommodation; Camping ground, recreational vehicle parks and Trailer parks (NB). Also, two specific tourism industries (Accommodation and Restaurants, and Bars and Tobacco Shops) were selected to carry out business-based investigation on the socio-economic impact of climate change on their supply in coastal regions of Italy for Accommodation and Restaurants, socio-economic variable include Number of Accommodation and Restaurants (NAR), Number of Persons Employed in Accommodation and Restaurants (NPEAR), and Wages of Employees in Accommodation and Restaurants (WEAR). For Bars and Tobacco shops, socio-economic variables include Number of Bars and Tobacco Shops (NBT), Number of Persons Employed in Bars and Tobacco Shops (NPEBT), Wages of Employees in Bars and Tobacco Shops (WEBT) and Gross Fixed Capital Formation (GFCF) which was aggregated for accommodation, food service activities (restaurants), wholesale and retail trade and transportation. There were no data on the amount of energy consumed by tourism operators (Accommodation and Restaurants) both at the regional level to analyze the impact of climate change on energy consumption in tourism operation, therefore, expert judgement will be applied to assess the risk impact of climate change on Cooling and Heating Systems (CHS) in Accommodation and Restaurants in the coastal regions. At the national level, observation is taken from 2008 to 2019 for all tourism demand and supply data. For the demand side, Total International Receipts (TIR) and Total International Expenditure (TIE) in

Tourism is sourced from the Organization for Economic Co-Operation and Development (OECD) Database, and NSTA from Eurostat. For the supply side, NE, NB, NAR, WEAR, NPEAR, NBT, WEBT, NPEBT and GFCF (data description as referred to the regional level) is sourced from Eurostat.

4.2 Method of Data Analysis

4.2.1 Climate Change in Italy and the Coastal Regions

At regional level, the timeseries of the temperature variations across the 6 coastal regions from year 1999 to 2019 are visualized using a timeseries plot. Their minimum and maximum temperature from the observed period were used to determine their ranges and the temperature changes across the 6 coastal regions from the observed period were determined by the difference between temperatures in 1999 and 2019. The magnitude of the rate of change in temperature in the 6 coastal regions, and how significant are the changes (if P-value <0.05) and the estimated rate on how temperature changes occur in respect to time is explained using correlation coefficient and linear regression model. These will be compared with the result for the control region (non-coastal region) using the same methods for coastal regions. At national level, the time series plot is used to visualize the trend of temperature variation within the observed period (2008 to 2019). The method used for the analysis of the regional temperature data is applied to the national temperature data.

4.2.2 Climate Change Impact on Tourism Demand and Supply in Coastal Zones

The time series of average temperature and the average tourism demand and supply variables for the 6 coastal regions in each of the observed year (1999 to 2019) are also visualized using time-series plot to see how consistent each variable is changing with temperature. The rate of increase of tourism demand and supply is determined by the difference between their values in 1999 and 2019. Correlation coefficient is used to determine the extent of relationship between temperature and the tourism demand and supply variable. A panel regression model (fixed effect and random effect) is used to examine how significant temperature has influence over tourism demand and supply in the coastal regions. Dataset for each coastal region is assembled to form a panel data, a dataset in which the behavior of entities is observed across time, also known as longitudinal or cross-sectional time-series data.

Fixed Effect

c_i is the unobserved effect, correlated with the covariates. Fixed effects methods transform the model to remove c_i.

Fixed Effect Transformation – the "Within" Estimator

Let the unobserved effect model be.

$$y_{it} = X'_{it}\beta + c_i + u_{it} \text{ ,}$$

t=1, 2……, T

The average of this equation over all period t will be calculated for each unit:

$$\bar{y_i} = \bar{X}'_{it}\beta + \bar{c}_i + \bar{u}_{it}$$

Subtract the within-unit average from each observation on that unit:

$$y_{it} - \bar{y_i} = X'_{it} - \bar{X}'_{it}\beta + c_i - \bar{c}_i + u_{it} - \bar{u}_{it} \text{ ,}$$

t=1, 2……, T

This is the fixed effect transformation. We can write it as:

$$\ddot{y}_{it} = \ddot{X}'_{it}\,\beta + \ddot{u}_{it} \text{ ,}$$

Where $c_i - \bar{c}_i = 0$ and $\ddot{y}_{it} = y_{it} - \bar{y_i}$, $\ddot{X}'_{it} = X'_{it} - \bar{X}_i$, $\ddot{u}_{it} = u_{it} - \bar{u}_i$

And $\ddot{X}_{it}$ does not contain an intercept term.

Therefore, the fixed effect model can be represented in R programming with the following code:

$$fixed_{effect_{model}} < -plm(y \sim X, data = name_{of_{database}},$$
$$index = ("period_t^{"}), model =^{"}\ within^{"})$$

Were,

plm = panel linear model for panel data

y = Tourism Demand and Supply Variables

X = Temperature

$name_{of_{database}}$ = the name where the database is read

$period_t$ = time when observations were made. Example "$Year$"

$within$ = defines the fixed effect model.

Random Effect

The random effect model is suitable if we assume that the unobserved heterogeneity will not bias the estimates. In other words, the “random effect assumption” of no bias due to c_i is more stringent.

$$E(c_i \mid X_{i1}, \ldots, X_{iT}) = E(c_i) = 0$$

A conventional random effect estimator assumes the following.

- That errors are correlated within each unit.
- That errors are uncorrelated across unit.
- That variance in the composite errors is equal to the sum of the variance in the unobserved effect c_i and the idiosyncratic error u_i:

$$\sigma_v^2 = \sigma_u^2 + \sigma_c^2$$

$$if\ \sigma_v^2 = \sigma_u^2 + \sigma_c^2, \text{find estimator such that } \hat{\sigma}_v^2 = \hat{\sigma}_u^2 + \hat{\sigma}_c^2$$

It is important to know that the random effect estimator essentially transforms the data by partially demeaning each variable. Instead of subtracting the entire unit-specific mean, only part of the mean is subtracted. The demeaning factor λ is between 0 and 1, with the specific value based on the variance components estimation.

Therefore, the random effect model can be represented in R programming with the following code:

$$random_{effect_{model}} < -plm(y \sim X, data = name_{of_{database}},$$
$$index = ("period_t"), model = "\ random")$$

Were,

plm = panel linear model for panel data

y = Tourism Demand and Supply Variables

X = Temperature

$name_{of_{database}}$ = the name where the database is read

$period_t$ = time when observations were made. Example "$Year$"

$random$ = defines the random effect model.

Choosing the suitable panel regression model (fixed effect or random effect) for the panel data

To decide between fixed or random effects, a Hausman test where the null hypothesis is that the preferred model is random effects vs. the alternative the fixed effects (Leta and Tegegn, 2018). It basically tests whether the unique errors are correlated with the regressors, the null hypothesis is they are not.

If the unobserved effect is exogenous, the fixed effect and the random effect are asymptotically equivalent. This suggests the null hypothesis for the Hausman test:

$$H_0 = \hat{\beta}_{RE} = \hat{\beta}_{FE},$$

Where and are coefficient vectors for the time varying explanatory variables, excluding the time variables. If the null hypothesis is rejected (p-value <0.05), we conclude that random effect is inconsistent, and the fixed effect is preferred.

Therefore, the Hausman test to choose between random effect model or fixed effect model suitable for the panel data analysis can be represented in R programming with the following code:

$$fixed_{effect_{model}} < -plm(y \sim X, data = name_{of_{database}},$$
$$index = ("period_t"), model =" within")$$

$$random_{effect_{model}} < -plm(y \sim X, data = name_{of_{database}},$$
$$index = ("period_t"), model =" random")$$

$$Hausman_{test} < -phtest(fixed_{effect_{model}}, random_{effect_{model}})$$

$$If\ the\ p - value\ is\ significant\ (< 0.05)\ then\ use\ fixed\ effects$$

4.2.3 Climate Change Impact on Tourism Demand and Supply in Non-Coastal Zone

The time series of the temperature and the tourism demand and supply variables for the control region (non-coastal region) in the observed period (1999 to 2019) are visualized using time-series plot to see how consistent each variable is changing with temperature. The rate of increase of tourism demand and supply is determined by the difference between their values in 1999 and 2019. Correlation coefficient is used to determine the extent of relationship between temperature and the tourism demand and supply variable in the control region. A linear regression model is used to examine how significant temperature has influence over tourism demand and supply in non-coastal region. This is represented by.

$$y = \beta_0 + \beta_1 X + \epsilon$$

y is the predicted value of the response variable (y) for any given value of the independent variable (X).

β_0 is the intercept, the predicted value of y when the X is 0.

β_1 is the regression coefficient – how much we expect to change as X increases.

X is the explanatory variable (the variable we expect is influencing y).

ϵ is the error of the estimate, or how much variation there is in our estimate of the regression coefficient.

In R programming, this will be coded as

$$linear\_regression\_model < -lm(y \sim X)$$

lm=the linear model

y = Tourism Demand and Supply Variables

X = Temperature

Result from the assessment of variables from coastal and non-coastal regions is compared.

4.2.4 Climate Change Impact on Tourism Demand and Supply in Italy at National Level

A linear regression model is used to examine how significant temperature has influenced tourism demand and supply at the national level in the observed period from 2008 to 2019. The formular is represented as stated in section 4.2.3. Correlation coefficient is used to determine the extent of relationship between temperature and the tourism demand and supply variable in the control region.

4.2.5 Climate Change Impact on Investment in Tourism in Italy at Regional (Coastal and Non-Coastal) and National Level

In assessing the impact of climate change on investment made in the tourism sector, the Gross Fixed Capital Formation (GFCF) for the tourism supply are considered. The concept of investment is very broad, however, based on this study, challenges in direct data collection on investment, the most efficient way to measure investment in the tourism supply is through GFCF. Gross Fixed Capital Formation is the amount of money spent on additional fixed assets as well as the change in inventory levels. These assets include machine purchases, land improvements, upgrades or changes to infrastructure, and inventories include the items that are still being produced as well as items firms keep in stock in the event their demand increases suddenly. On sectoral basis, GFCF can easily be analyzed, which makes it the indicator to compare the effect of climate change on investments (Rojas Cama and Emara, 2022). The GFCF for tourism supply is an aggregated data from Accommodations, Restaurants, Wholesale and Retail Trades and Transportation, sourced from Eurostat.

A linear regression model was used to analyze the influence of temperature changes on investments in tourism supply at the national level and the non-coastal region using the formular as represented in section 4.2.3, while a panel regression model (random effect) was used for the coastal regions. The relationship between temperature changes and investment in tourism supply at national level and regional level (coastal and non-coastal) were determined by their correlation coefficients.

4.2.6 Relationship Between Tourism Demand, Supply, and Investment in a Changing Temperature in Italy.

To examine the relationship between tourism demand, supply, and investment holistically in a changing climate, the correlogram approach will be used to visualize the extent of relationship existing between each parameter. This approach is applied to both the regional and national level in Italy and compared.

4.3 Climate Change Risk, Adaptation and Vulnerability Assessment

The method for the risk assessment of climate change (Temperature increase) on tourism demand and supply is referenced from the Climate Change Risk Adaptation Assessment (CCRAA) Framework for Infrastructure developed by the State of Queensland (Department of Transport and Main Roads) 2020 (The State of Queensland, 2020; Brundell et al, 2011). This framework was developed in line with relevant standards and current guidelines for assessing the climate risks in accordance with AS 5334:2013 Climate Change Adaptation for Settlement and Infrastructure – A risk-based approach and the department EP170 Climate Change Risk Assessment Methodology. The following steps is undertaken to carry out climate change risk and adaptation assessment on tourism demand and supply in line with both AS 5334:2013 and the Australian Government's Guide for Business and Government:

A. Identify the key climate variable and the climate variability.
    - Identify climate variability.
    - Assign likely change in climate patterns.
    - Identify key elements for tourism demand and supply.

B. Completion of Climate Change Risk Assessment (CCRA), with risk rating (Table 1.0), evaluated using the AS5334 Risk Management Framework, including likelihood (Table 3.0) and consequence criteria (Table 4.0)
   - Describe impact for climate variability and tourism demand and supply parameters.
   - Determine likelihood categories.
   - Determine consequences categories.
   - Assign impact risk.

C. Consequence ratings have been selected based on the highest rating for the risk categories.

D. Identification of measures to mitigate and adapt to the identified climate change risk.
   - Describe adaptation responses.
   - Determine adaptation capacity.
   - Assign level of vulnerability (Table 2.0).

E. Risk and Vulnerability Statement, and action plan.
   (Brundell et al, 2011; The State of Queensland, 2020)

4.3.1 Assigning Risk Impact using Risk Impact Matrix

In the concept of climate change, according to IPCC 6th Assessment Report, risk can arise from potential impacts of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, livelihood, health and wellbeing, economics, social and cultural assets and investment, infrastructure, services (including ecosystem services), ecosystems and spaces (IPCC, 2022). Risk results from the interaction of vulnerability (of the affected system), its exposure over time (to the hazard), as well as the (climate-related) hazard and the likelihood (IPCC, 2022). Consequence categories of temperature changes will be ranked based on significant p-value of temperature from panel regression analysis and likelihood categories will be ranked based on the significant influence of temperature on the tourism demand and supply variables using the GP formatting of p-values derived from results from panel regression, and expert judgement (UNCC, 2023). Level of impact (Extreme, High, Medium, Low) is derived by combining likelihood and consequence categories.

4.3.2 Definition of the impact Risk Categories

The definition of the impact risk categories will be based on negative or opposite influence of temperature increase on tourism demand and supply parameters (Brundell et al, 2011).

Extreme (Negative): This level of impact risk demands urgent attention at the senior leadership level of industry and government. Effective responses are always transformational and not part of routine action.

High (Negative): This level of impact risk needs attention of senior level of industry executive, agency management and policy development. More senior industry and government representatives need briefings. Effective responses are usually transformational and not generally incremental routine actions.

Medium (Negative): this level of impact risk needs close monitoring and reporting at senior level (industry executives, agency senior management, pastoral company board, NRM group executives). Effective responses may be incremental and part of routine action.

Low (Negative): This level of impact risk requires that they be maintained under review, but existing controls should be sufficient, and no further action is required unless the status changes (Brundell et al, 2011; The State of Queensland, 2020).

4.3.3 Adaptation Responses and Determining Adaptive Capacity

According to the IPCC 6th Assessment Report, adaptation (in human system) is the process of adjustment to actual or expected climate and its effects, to moderate harm or exploit beneficial opportunities. An *Incremental* adaptation is one that maintains the essence and integrity of a system or process at a given scale. In some cases, incremental adaptation can accrue to result in transformational adaptation. A *transformational* adaptation is one that changes the fundamental attributes of a socio-ecological system in anticipation of climate change and its impacts. Adaptive capacity is the ability of a system, institution, human and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC, 2022). The adaptive capacity will be determined according to the guideline below (Table 2.0).

Low: A low level of adaptative capacity means it is very difficult and costly for the business, region, or industry to implement adaptive activities that are effective.

Medium: A medium level of adaptative capacity perceives some difficulty and expense in implementing changes; however, it is possible.

High: A high level of adaptive capacity is where adaptation is feasible and practical (Brundell et al, 2011; The State of Queensland, 2020).

4.3.4 Assigning Level of Vulnerability

Vulnerability is the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2022). Level of vulnerability will be determined by using the impact risk determined in the impact risk matrix with adaptive capacity determined (Table 2.0) to derive the level of vulnerability to climate change (Brundell et al, 2011; The State of Queensland, 2020).

Level of Impact					
	Consequences				
Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	Medium	High	Extreme
Possible	Low	Low	Medium	High	Extreme
Unlikely	Low	Low	Medium	Medium	High
Very Unlikely	Low	Low	Low	Medium	Medium

Table 1.0: Risk rating matrix adopted from AS5334-2013 Climate Change Adaptation for Settlement and Infrastructure (Brundell et al, 2011; The State of Queensland, 2020).

	Adaptive Capacity		
Impact	Low	Medium	High
Extreme	High	High	Moderate
High	High	Moderate	Moderate
Medium	Moderate	Moderate	Low
Low	Low	Low	Low

Table 2.0: Level of Vulnerability adopted from AS5334-2013 Climate Change Adaptation for Settlement and Infrastructure (Brundell et al, 2011; The State of Queensland, 2020).

Likelihood	Description	Recurrent or Event Risks	Long Term Risks
Almost Certain	Could occur several times per year	Has happened several times in the past year and in each of the previous 5 years or Could occur several times per year	Has a greater than 90% chance of occurring in the identified time period if the risk is not mitigated
Likely	May arise about once per year	Has happened at least once in the past year and in each of the previous 5 years, or May arise about once per year	Has a 60–90% chance of occurring in the identified time period if the risk is not mitigated
Moderate	Maybe a couple of times in a generation	Has happened during the past 5 years but not in every year, or May arise once in 25 years	Has a 40–60% chance of occurring in the identified time period if the risk is not mitigated
Unlikely	Maybe once in a generation	May have occurred once in the last 5 years, or May arise once in 25 to 50 years	Has a 10–30% chance of occurring in the future if the risk is not mitigated
Very Unlikely (Rare)	Maybe once in a lifetime	Has not occurred in the past 5 years or Unlikely during the next 50 years	May occur in exceptional circumstances, i.e. less than 10% chance of occurring in the identified time period if the risk is not mitigated

Table 3.0: Likelihood Criteria adopted from AS5334-2013 Climate Change Adaptation for Settlement and Infrastructure (Brundell et al, 2011; The State of Queensland, 2020)

Consequence	Adaptive Capacity	Infrastructure, Service	Social / Cultural	Governance	Financial	Environmental	Economy
Insignificant	No change.	No infrastructure damage, no change to service.	No adverse human health effects.	No changes to management required.	Little financial loss or increase in operating expenses.	No adverse effects on natural environment.	No effects on the broader economy.
Minor	Minor decrease to the adaptive capacity of the asset. Capacity easily restored.	Localised infrastructure service disruption. No permanent damage. Some minor restoration work required. Early renewal of infrastructure by 10-20%. Need for new/ modified ancillary equipment.	Short-term disruption to employees, customers or neighbours. Slight adverse human health effects or general amenity issues.	General concern raised by regulators, requiring response action.	Additional operational costs Financial loss small, <10%.	Minimal effects on the natural environment.	Minor effect on the broader economy due to disruption of service provided by the asset.
Moderate	Some change in adaptive capacity. Renewal or repair may need new design to improve adaptive capacity.	Limited infrastructure damage and loss of service. Damage recoverable by maintenance and minor repair. Early renewal of infrastructure by 20-50%.	Frequent disruptions to employees, customers or neighbours. Adverse human health effects.	Investigation by regulators Changes to management actions required.	Moderate financial loss 10-50%.	Some damage to the environment, including local ecosystems. Some remedial action may be required.	High impact on the local economy, with some effect on the wider economy.
Major	Major loss in adaptive capacity. Renewal or repair would need new design to improve adaptive capacity.	Extensive infrastructure damage requiring major repair. Major loss of infrastructure service. Early renewal of infrastructure by 50-90%.	Permanent physical injuries and fatalities may occur. Severe disruptions to employees, customers or neighbours.	Notices issued by regulators for corrective actions. Changes required in management. Senior management Responsibility questionable.	Major financial loss 50-90%.	Significant effect on the environment and local ecosystems. Remedial action likely to be required.	Serious effect on the local economy spreading to the wider economy
Catastrophic	Capacity destroyed, redesign required when repairing or renewing asset.	Significant permanent damage and/or complete loss of the infrastructure and the infrastructure service. Loss of infrastructure support and translocation of service to other sites. Early renewal of infrastructure by 90%.	Severe adverse human health effects, leading to multiple events of total disability or fatalities. Total disruption to employees, customers or neighbours. Emergency response at a major level.	Major policy shifts. Change to legislative requirements	Extreme financial loss > 90%.	Very significant loss to the environment. May include localised loss of species, habitats or ecosystems. Extensive remedial action essential to prevent further degradation. Restoration likely to be required.	Major effect on the local, regional and state economies.

Table 4.0: Consequence Criteria adopted from AS5334-2013 Climate Change Adaptation for Settlement and Infrastructure (Brundell et al, 2011; The State of Queensland, 2020)

5.0 Results

5.1 Results from Temperature Data Analysis

Temperature data was considered in this assessment because it is an important climatic factor to determine the development of tourism (Jonathon et al, 2021; Peter, 2021). At the regional level, data were analyzed using a timeseries plot, correlation coefficient and simple linear regression model (See Appendix 1.0). A time series line plot is a display of the data observation against time along the horizontal axis. Correlation is a measure of a monotonic association between two variables in which as one variable increases, so the other increases. The linear relationship between the two variables is a special case between a coefficient of 0 to 1 (positive relationship) or 0 to -1 (negative relationship), which explains the degree to which the change in one continuous variable is associated with a change in another continuous variable (Schober, 2018). Linear regression is a statistical test applied to a dataset to define and quantify the relationship between the considered variables. Both correlation and regression provide this opportunity to understand the risk factors of temperature increase. While correlation provides a quantitative way of measuring the degree or strength of the relationship between two variables, regression analyses mathematically describe their relationship (Kumari and Yadav, 2018). Figure 2.0 shows a graphic visualization of trends in the observed period (year 1999 to 2019) in the 6 coastal regions and the control (non-coastal) region, for annual time series. The plot for each of the regions shows an increasing trend in temperature with a sharp reduction in temperature occurring in the year 2005, 2010 and 2015 but obviously in year 2010, corresponding to the La Nina cooling event (Kurk et al, 2011). Table 5.0 shows at regional level (the six coastal regions and the control (non-coastal) region), the minimum and maximum temperatures during the observed period (1999 to 2019), the temperature rise during the observed period which were derived from the difference between the temperatures recorded in year 1999 and the temperatures recorded in 2019, with their respective significant changes with time using a p-value < 0.05, and estimated rate at which temperature was changing in respect to time. Campania and Sicilia have very weak correlation coefficient value of 0.38 and 0.35 with respective no significance p-value > 0.05 (0.0859 and 0.116), while Abruzzo and Sardegna has a Moderate correlation coefficient of 0.60 and 0.68 with respective 95% and 99% significance. In the observed period, Abruzzo and Valle d' Aosta demonstrate the highest temperature rise of 1.12^{o}C and 1.78^{o}C respectively while Calabria and Sicilia demonstrate the lowest temperature rise of 0.65^{o}C and 0.32^{o}C. This low rate of temperature change in Calabria and Sicilia can be explained by the influence of the Ionian Sea bothering both regions in the north. At the national level in Italy (Table 5.0) from the observed period from 2008 to 2019, there is 90% significant change of 0.0344 with a moderate correlation coefficient of 0.61 with an estimated rate of change of Temperature of 0.07^{o}C (Appendix 1.7), where the maximum and minimum temperature of 14.72^{o}C and 13.15^{o}C are respectively observed in year 2017 and 2010 (Figure 2.1). The minimum temperature observed at the national level in Italy in year 2010 also corresponds La Nina cooling event (Kurk et al, 2011).

Regions	**Min (^{o}C)**	**Max (^{o}C)**	**Range (^{o}C)**	**(^{o}C) (1999)**	**(^{o}C) (2019)**	**(^{o}C) Changes**	**Sign. P-value < 0.05**	**Est. Rate of Change**	**Corr. Coef**
Liguria	12.63	14.4	1.77	13.41	14.4	0.99	0.0194*	0.037	0.51 (*Moderate*)
Abruzzo	16.77	18.08	1.31	16.96	18.08	1.12	0.0039**	0.033	0.60 (*Moderate*)
Campania	15.02	16.63	1.61	15.73	16.63	0.9	0.0859	0.024	0.38 (Weak)
Calabria	16.58	17.86	1.28	17.21	17.86	0.65	0.0362*	0.027	0.45 (*Moderate*)
Sicilia	17.48	18.64	1.16	18.12	18.44	0.32	0.116	0.018	0.35 (Weak)
Sardegna	18.15	19.26	1.11	18.29	19.08	0.79	0.00078***	0.038	0.68 (*Moderate*)
Valle d' Aosta	2.75	5.51	2.76	3.73	5.51	1.78	0.0266*	0.049	0.48 (*Moderate*)
Italy	13.15	14.72	1.59	14.24 **(2008)**	14.56	0.32	0.0344*	0.0713	0.61 (*Moderate*)

Regression Interpretation
*** Extremely (99%) significant ** Very (95%) significant * (90%) Significant No Significance
Gaasbeck (2018)

Correlation Coefficient Interpretation
0.0 - 0.10 (*Negligible*) , 0.40 – 0.69 (*Moderate*), 0.90 – 1.00 (*Very Strong*), 0.10 – 0.39 (*Weak*), 0.70 – 0.89 (*Strong*)
Schober et al (2018)

Table 5.0: Summary of Temperature Analysis for Italy, the 6 Coastal regions and the control (non-coastal regions).

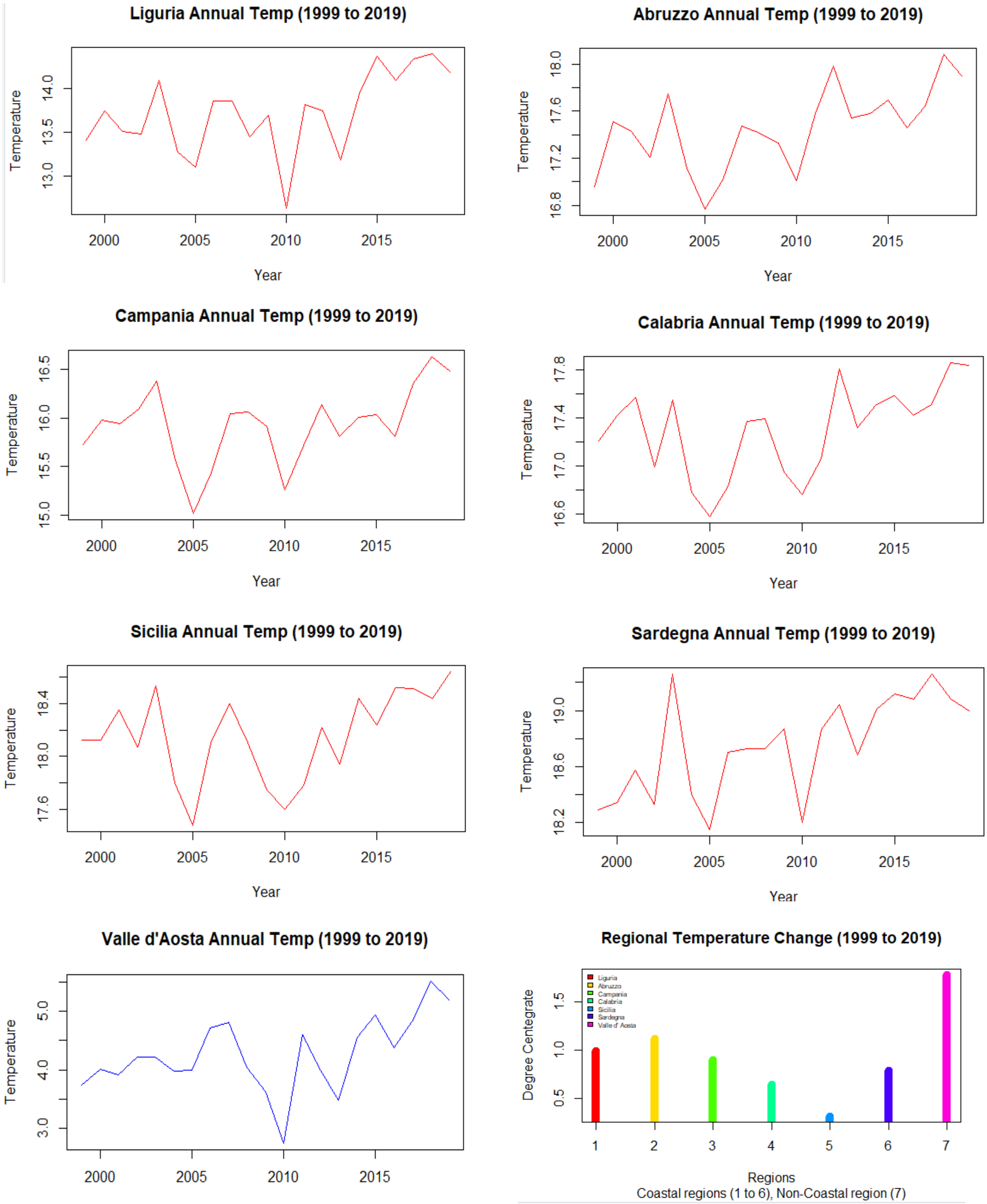

Figure 2.0: Annual temperature time-series plot for Liguria, Abruzzo, Campania, Calabria, Sicilia, Sardegna and Valle d' Aosta (control) regions

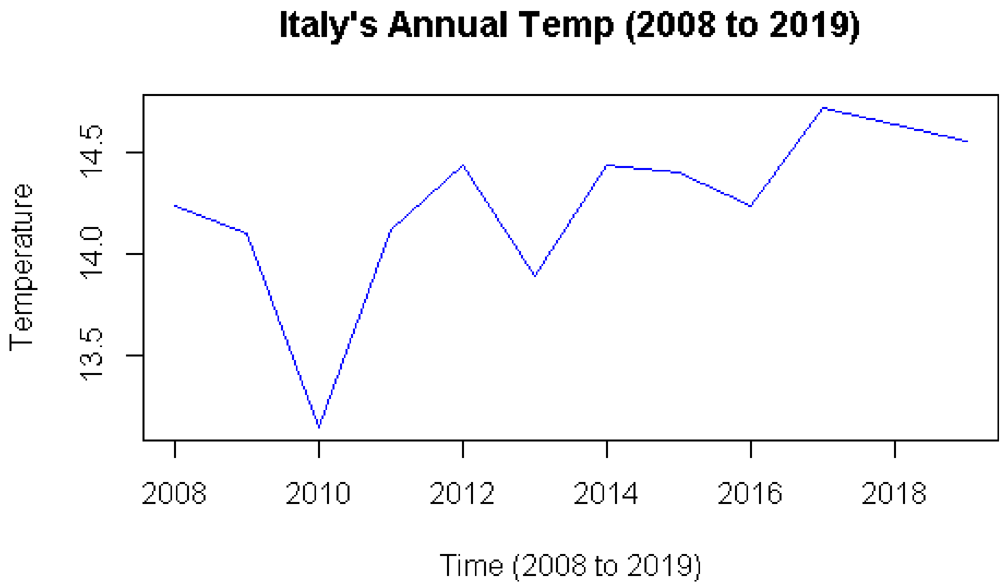

Figure 2.1: Annual temperature time-series plot for Italy from year 2008 to 2019

5.2 Results from Tourism Demand and Supply Impact Assessment in Coastal Zones of Italy.

The tourism demand and supply variables were recorded repeatedly in the same location in the different study regions which requires a cross-sectional analysis of influence of factor variables on resultative variables. The processing of such data results in the appearance of panel data. The process of analyzing panel data was first applied in sociological problems, and later applied in research of microeconomics indicators dynamics, due to the increase of interest of studying events at the macroeconomic level. Application has also been applied in microeconomics involving research in investigating features and behavior of companies, labor force and consumers, and business project and performance that occur over time and is subject to multiple risks. Panel data is a statistical observation that shows a variation of entities features contributing to the increase of variability of observation and accuracy of estimation. To analyze panel data, the absence of recorded data homogeneity will be observed due to the changes in the behavior of the variables in time. In this case, contrasts between coefficients should be used to define which of the canonic models: fixed effects model (individual or temporal) or composed error model (random effects) using a *Hausman Test*, were the null hypothesis is that the preferred model is fixed effect with a significant p-value<0.05, or else, random if p-value>0.05. In the case of fixed effect models, it is assumed that the influence of considered factor variables on the dependent variable is identical for all entities during the entire analyzed period, while the case of random effects, the random character of specific effects differentiates composed effect model from fixed effect models (Jaba et al, 2017).

Results (Table 6.0) from the panel data analysis (See Appendix 2.0) on the tourism parameter reveal that observed temperature increase may have influence over tourism demand and supply in coastal zones of Italy. From the demand side, Night Spent at Tourist Accommodation (NSTA) shows 90% significant influence of p-value 0.01413 from temperature with a moderate correlation coefficient of 0.5926. from the supply side, Number of Establishments (NE) and Number of Beds (NB) shows 99% extremely significant influence of p-values of $1.36e^{-05}$ and 0.00027 respectively from temperature with a moderate correlation coefficient of 0.5133 and 0.5107 respectively, but there is an observed opposite effect in Nb with an estimate value of -19.7982. These correspond with the time series plot which shows a consistency in trend between temperature and the NSTA, NE and NB. Also, result from assessment (Table 6.0) of two selected tourism businesses (Accommodation and Restaurants, and Bars and Tobacco Shops) based on availability of sufficient data of at least 20 years, revealed that observed temperature increase may have influence on some tourism businesses and have some socio-economic impact in the tourism operators.

From the Accommodation and Restaurants businesses, Number of Accommodation and Restaurants (NAR) and Number of Persons Employed in Accommodation and Restaurants (NPEAR) shows 99% extremely significant influence with p-value of 0.00014 and $5.44e^{-05}$ respectively from temperature change with a weak correlation coefficient of 0.3859 and a moderate correlation coefficient of 0.4506 respectively, with an opposite effect on NPEAR of estimate value of -10.7724. Employees in Accommodation and Restaurants (WEAR) show no significant influence from temperature changes.

From the assessment of the level of influence temperature changes has on Bars and Tobacco shops on the coastal zones of Italy, results (Table 6.0) revealed that temperature changes has no significant influence in the Number of Bars and Tobacco shops (NBT), but has 99% extremely significant influence of p-value of 0.00036 and 0.00014 on the Number of Persons Employed in Bars and Tobacco Shops (NPEBT), and Wages of Employees in Bars and Tobacco Shops (WEBT) respectively but with an opposite effect of estimate value of -9.0953 and -16.5731. These correspond with the time series plot which shows a consistency in trend between temperature and NPEBT and WEBT.

On investment in tourism supply, result (Table 9.0) revealed that temperature changes have no significant influence on the investment in tourism supply at regional in the coastal zone.

5.3 Results from Tourism Demand and Supply Impact Assessment in Non-Coastal Zone of Italy.

Methods of the assessment of the influence of temperature changes on tourism supply and demand in non-coastal zone of Italy was referenced from the temperature data analysis (Section 5.1 of this thesis), because data for the non-coastal region was collected from a single region as a control variable. In otherwards, correlation coefficient and linear regression were applied (See Appendix 3).

Result (Table 7.0) revealed that temperature changes in the non-coastal zones may have influence on demand and supply but on the contrary, has no influence on individual tourism businesses specifically and their socio-economic factors. From the demand side, there is an observed 90% significant influence of temperature change on Night Spent on Tourism Apartments (NSTA) with a p-value 0.0134 and a moderate correlation coefficient of 0.5300. Also from the supply side, there is an observed 90% significant influence of temperature changes on Number of Beds (NB) with p-value 0.0455 and a moderate correlation coefficient of 0.4408, but there was no observed influence of temperature changes on Number of Tourism establishments (NE). From the assessment of how temperature change influences tourist businesses (Accommodation and Restaurants, and Bars and Tobacco Shops) in the non-coastal zones of Italy, results (Table 7.0) shows no evidence of influence on the Number of Accommodation and Restaurants (NAR), Number of Persons Employed in Accommodation and Restaurants (NPEAR), Number of Bars and Tobacco Shops (NBT), Number of Persons Employed in Bars and Tobacco Shops (NPEBT) and Wages of Employees in Bars and Tobacco Shops (WEBT), but evidence of temperature change influence was observed in Wages of Employee in Accommodation and Restaurants (WEAR) with 95% significant p-value of 0.00769 and correlation coefficient of 0.5644.

On investment in tourism supply, result (Table 9.0) revealed that temperature changes have no significant influence on the investment in tourism supply at regional in non-coastal region.

5.4 Results from Tourism Demand and Supply Impact Assessment in Italy at the National Level.

The same method for the assessment of the influence of temperature changes on tourism demand and supply in non-coastal zone of Italy was applied to the assessment of the influence of temperature changes on tourism demand and supply in Italy at the national level.

Result (Table 8.0) revealed that temperature changes still may have influence on the demand and supply of tourism at the national level but may neither have influence on individual tourism businesses specifically and their socio-economic factors. From the demand side, there is 90% significant influence of temperature changes on Night Spent on Tourism Apartment (NSTA) and Total International Receipt (TIR) from tourism with a p-value of 0.0285 and 0.0125, with a moderate correlation coefficient of 0.6287 and 0.6929, all respectively. Also, temperature changes have 95% significant influence on the Total International Expenditure (TIE) from tourism at the p-value of 0.0046 and a strong correlation coefficient of 0.7535. From the supply side, there is an observed 90% significant influence of temperature changes on the Number of Beds (NB) and Number of Establishments (NE) with a p-value of 0.0177 and 0.0344 with a moderate correlation coefficient of 0.6671 and 0.6119, all respectively. NSTA and NB corresponds with the result at the regional level (coastal and non-coastal), while at the regional level, temperature changes demonstrate an extremely significant influence with a negative impact on NE, there is a significant influence and a positive impact at national level. From the assessment of the influence of temperature changes on tourism businesses (Accommodation and Restaurants,, and Bars and Tobacco Shops) in Italy at the national level, result (Table 8.0) shows no evidence of influence on the Number of Accommodation and Restaurants (NAR) but has a 90% significant influence on the Wages of Employees in Accommodation and Restaurants (WEAR) and Number of Persons Employed in Accommodation and Restaurants (NPEAR) with p-values of 0.0212 and 0.0138 with a moderate correlation coefficient of 0.6533 and 0.6857, all respectively. Number of Bars and Tobacco Shops (NBT), Wages of Employees in Bars and Tobacco Shops (WEBT) and Number od Persons Employed in Bars and Tobacco Shops demonstrate no significant influence of temperature changes but a negative impact at the national level, which corresponds to the negative impact at the regional level (coastal region).

On investment in tourism supply, result (Table 9.0) revealed that temperature changes have 90% significant influence at the national level with a p-value of 0.0198 with a moderate correlation coefficient of 0.6587.

Because of insufficient explanatory evidence on how temperature affects tourism supply at national level as seen in the R-squares which falls between 0% to 56% (table 8.0), further analysis was carried out using a multiple regression model to assess the combined effect of temperature and tourism demand on tourism supply.

This is, however, represented by.

$$y = \beta_0 + \beta_1 X_1 + \cdots + \beta_n X_n + \epsilon$$

y is the predicted value of the response variable (y) for any given value of the independent variable (X).

β_0 is the intercept, the predicted value of y when the X is 0.

$\beta_1 X_1$ is the regression coefficient (β_1) of the first explanatory variable (X_1), the effect that increasing the value of the explanatory variable has on the response y Value

…. Do the same for however many explanatory variables are tested.

$\beta_n X_n$ is the regression coefficient of the last explanatory variable.

X is the explanatory variable (the variable we expect is influencing y).

ϵ is the error of the estimate, or how much variation there is in our estimate of the regression coefficient.

In R programming, this will be coded as

$$multiple\_linear\_regression\_model < -lm(y \sim X_1 + X_2 + X_n)$$

lm=the linear model

y = Tourism Supply Variables

X_1 = Temperature

X_2 = Tourism Demand Variable (NSTA)

X_n=The last Tourism Demand Variable (TIE)

Result from the multiple linear regression model (Table 10.0) which assesses the combined effect of temperature and tourism demand on tourism supply at national level revealed very strong significant effect of temperature and tourism demand variable (NSTA and TIE) on tourism supply NE, NB, GFCF with respective p-values of 0.0004, 4.6e-07, and 5.9e-05, which can be explained, with temperature indicating a negative effect, and on specific industries, significant effect was observed in wages of employee (WEAR) and number of employees (NPEAR) in the accommodation and restaurant sector, and number of employees (NPEBT) in the bars and tobacco sector, with p-values of 1.7e-05, 0.0001, and 0.03561 respectively, which can be explained, also, with temperature indicating a negative effect. There were no significant effect of temperature and tourism demand on number of accommodation and restaurants (NAR), number of gars and tobacco shops (NBT) and wages of employee in bars and tobacco shops (WEBT).

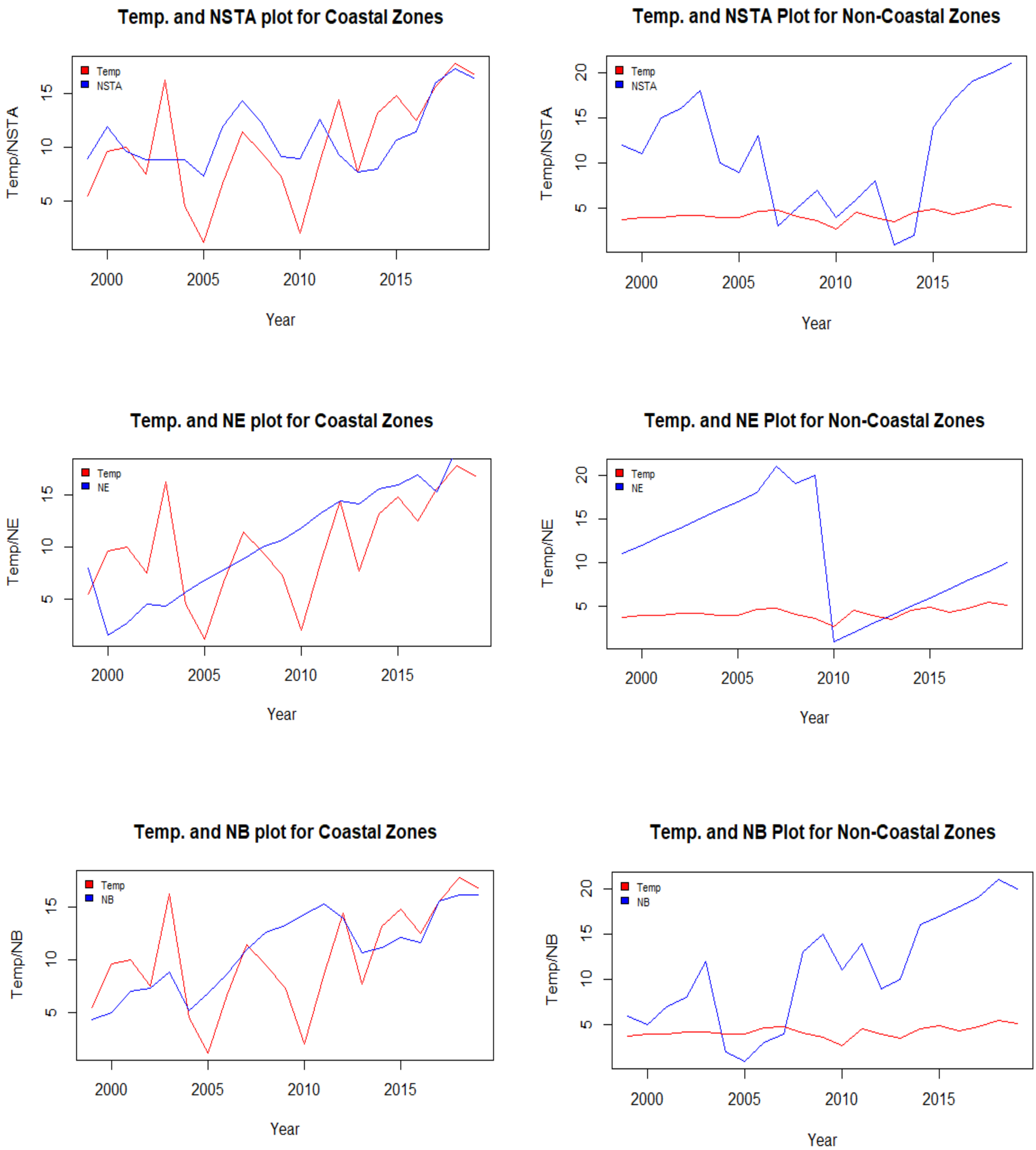

Figure 4.0 (a): Comparison of the consistency of the demand and supply variables (NSTA, NE, NB) in coastal and non-coastal region with temperature.

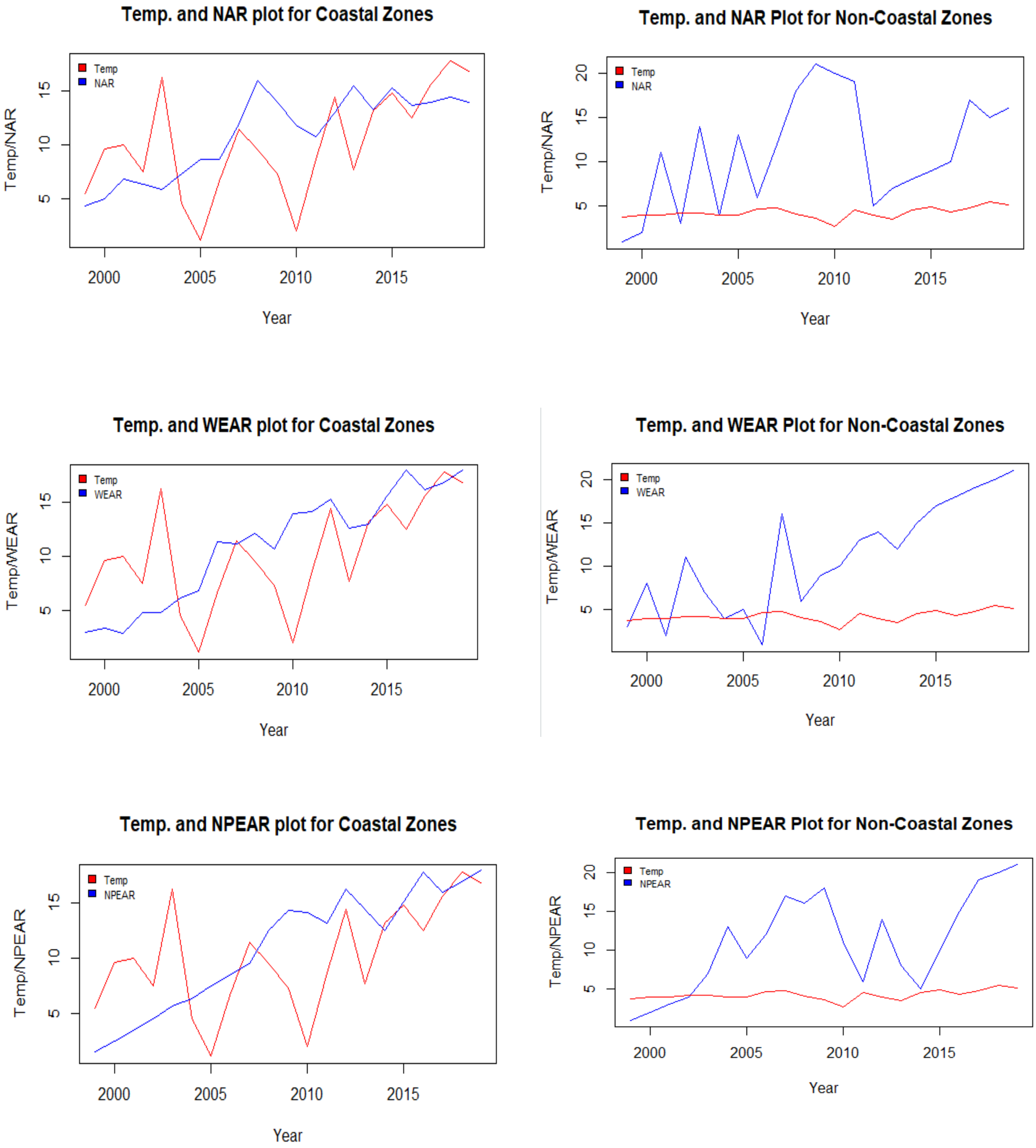

Figure 4.0 (b): Comparison of the consistency of the demand and supply variables (NAR, WEAR, NPEAR) in coastal and non-coastal region with temperature.

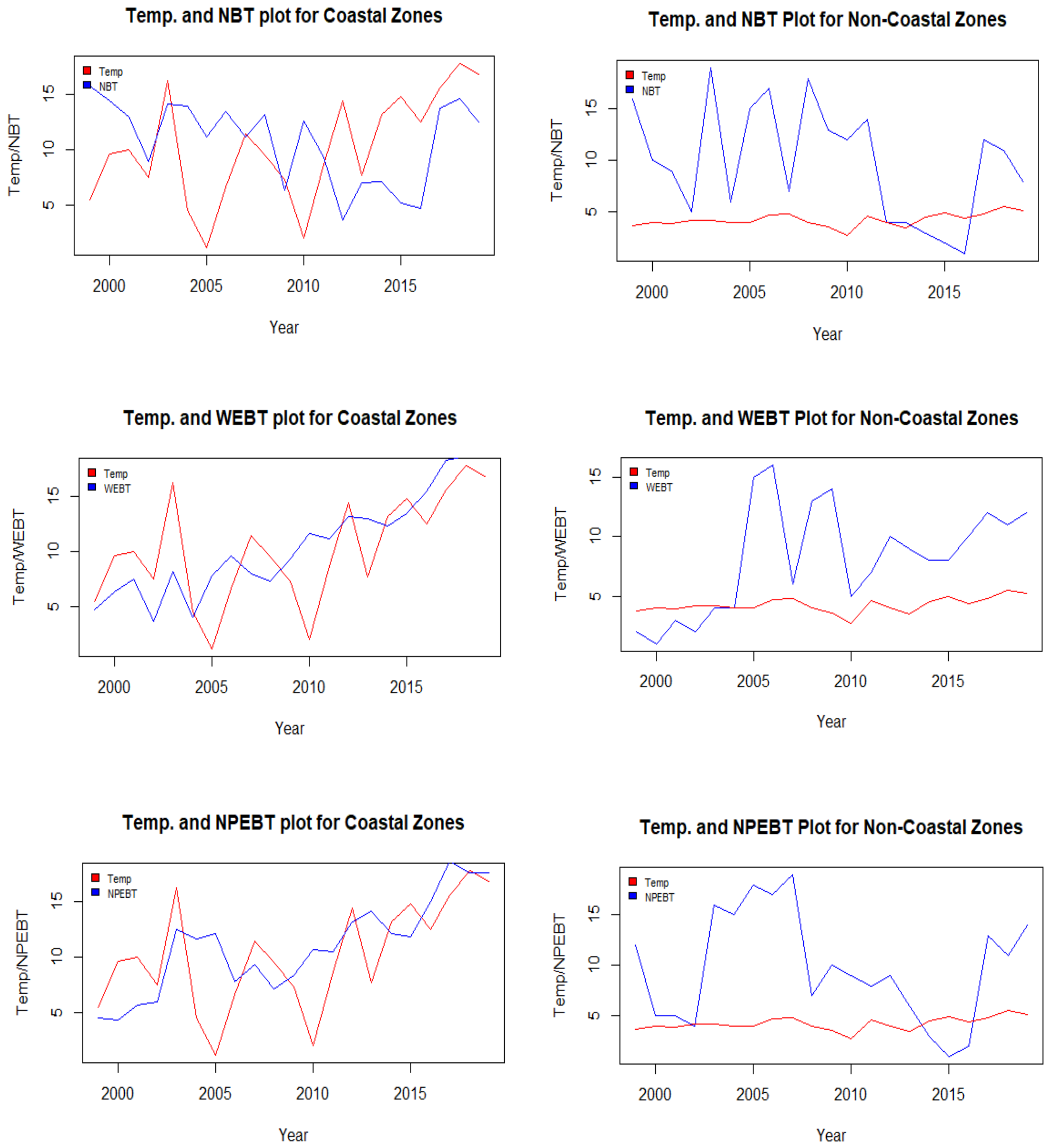

Figure 4.0 (c): Comparison of the consistency of the demand and supply variables (NBT, WEBT, NPEBT) in coastal and non-coastal region with temperature.

Regression results for Coastal Zones (Temperature as explanatory variable)						
Tourism Var. (Response Var.)	**Housman Coeff.**	**Applied Model**	**Corr. Coeff.**	**p-value (<0.05)**	**Estimate**	**R-Squared**
Demand Side						
NSTA	0.1099	Random eff.	0.5926	0.01413*	5.6483	0.0463
Supply Side						
NE	0.0008	Fixed eff.	0.5133	$1.36e^{-05}$***	-19.7982	0.1670
NB	0.0525	Random eff.	0.5107	0.00027***	10.5000	0.0960
Business Based (Accommodation and Restaurants)						
NAR	0.7732	Random eff.	0.3859	0.00014***	9.8234	0.1046
WEAR	0.2980	Random eff.	0.4698	0.7919	0.8102	0.0005
NPEAR	0.06	Random eff.	0.4506	$5.44e^{-05}$***	-10.7724	0.1160
Business Based (Bars and Tobacco Shops)						
NBT	0.9639	Random eff.	-0.1315	0.1220	-4.6099	0.0189
WEBT	0.0156	Fixed eff.	0.6415	0.00014***	-16.5731	0.1300
NPEBT	0.6162	Random eff.	0.5401	0.00036***	-9.0953	0.0930

Table 6.0: Regression results for Coastal Zones (Temperature as explanatory variable)

Regression results for Non-Coastal Zones (Temperature as explanatory variable)					
Tourism Var. (Response Var.)	**Applied Model**	**Corr. Coeff.**	**p-value (>0.05)**	**Estimate**	**R-Squared**
Demand Side					
NSTA	Linear regression	0.5300	0.0134*	5.2110	0.2432
Supply Side					
NE	Linear regression	0.0736	0.7510	0.7243	-0.0469
NB	Linear regression	0.4408	0.0455*	4.3340	0.1519
Business Based (Accommodation and Restaurants)					
NAR	Linear regression	0.0536	0.8170	0.5271	-0.0496
WEAR	Linear regression	0.5644	0.0076**	5.5490	0.2827
NPEAR	Linear regression	0.4076	0.0666	4.0070	0.1223
Business Based (Bars and Tobacco Shops)					
NBT	Linear regression	-0.1254	0.5880	-1.0970	-0.0360
WEBT	Linear regression	0.2910	0.2010	2.1010	0.0365
NPEBT	Linear regression	0.1299	0.5750	1.1220	-0.0348

Table 7.0: Regression results for Non-Coastal Zones (Temperature as explanatory variable)

Regression results for Italy at the national level (Temperature as explanatory variable)					
Tourism Var. (Response Var.)	**Applied Model**	**Corr. Coeff.**	**p-value (<0.05)**	**Estimate**	**R-Squared**
Demand Side					
NSTA	Linear regression	0.6287	0.0285*	5.3950	0.3953
TIR	Linear regression	0.6929	0.0125*	5.9450	0.4802
TIE	Linear regression	0.7535	0.0046**	6.4650	0.5679
Supply Side					
NE	Linear regression	0.6119	0.0344*	5.2500	0.3745
NB	Linear regression	0.6671	0.0177*	5.7240	0.4451
Business Based (Accommodation and Restaurants)					
NAR	Linear regression	0.3257	0.3014	2.7950	0.1061
WEAR	Linear regression	0.6533	0.0212*	5.6060	0.4269
NPEAR	Linear regression	0.6857	0.0138*	5.8840	0.4703
Business Based (Bars and Tobacco Shops)					
NBT	Linear regression	-0.2567	0.4204	-2.2030	0.0659
WEBT	Linear regression	-0.1949	0.5437	-1.6730	0.0380
NPEBT	Linear regression	-0.0959	0.7666	-0.8236	0.0092

Table 8.0: Regression results for Italy at the national level (Temperature as explanatory variable)

Regression results for Investment (GFCF) (Temperature as explanatory variable)						
Tourism Var. (Response Var.)	**Housman Coeff.**	**Applied Model**	**Corr. Coeff.**	**p-value (<0.05)**	**Estimate**	**R-Squared**
Coastal Region						
GFCF	0.2532	Random eff.	-0.0504	0.7096	1.1440	0.0001
Non-Coastal Region						
GFCF	NA	Linear	0.15869	0.4920	1.5600	0.0251
Italy (National Level)						
GFCF	NA	Linear	0.6587	0.0198*	5.6520	0.4340

Table 9.0: Regression results for Investment (GFCF) (Temperature as explanatory variable)

Multiple regression result s of the combined effect of temperature and tourism demand on tourism supply at the national level					
Tourism Var.	Explanatory Variables (Temp, NSTA, TIE)				
(Response Var.)	P-value (<0.05)	R-squared	Temp	NSTA	TIE
Supply Side					
NE	0.0004	0.8842	-0.8696	0.4530	0.5686
NB	4.6e-07	0.9791	-0.8040	0.3423	0.7241
Tourism investment					
GFCF	5.9e-05	0.9293	-0.9605	0.1683	0.8823
Business Based (Accommodation and Restaurants)					
NAR	0.467	0.2598	1.8331	1.0011	-0.6865
WEAR	1.7e-05	0.9482	-1.0562	0.2349	0.8344
NPEAR	0.0001	0.9144	0.4127	0.5281	0.4055
Business Based (Bars and Tobacco Shops)					
NBT	0.7772	0.1217	-3.5748	0.3932	-0.1160
WEBT	0.6207	0.1890	-4.108	-1.395	1.540
NPEBT	0.03561	0.6380	-7.6111	0.5076	0.6263

Table 10.0: Multiple regression result s of the combined effect of temperature and tourism demand on tourism supply at the national level

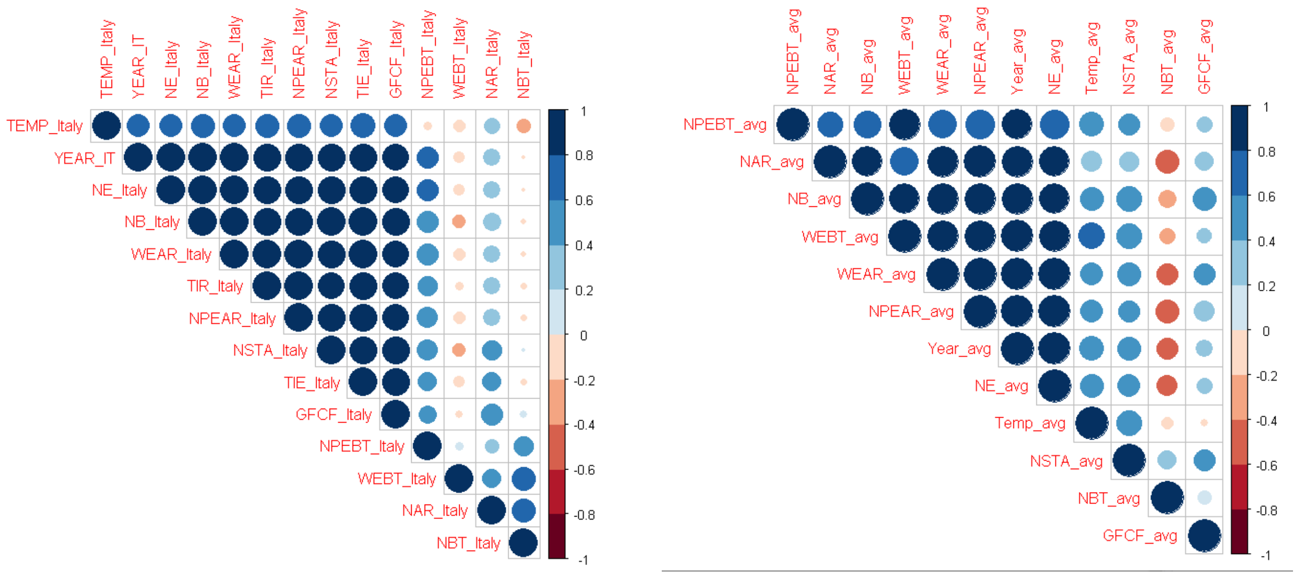

Figure 3.0: Comparing the Relationship Between Temperature, Tourism Demand, Supply, and Investment in at the national level (left) and the regional level (right) in Italy.

5.5 Result for Risk and Vulnerability Assessment

The scope of the risk and vulnerability assessment covers tourism businesses which include accommodation, restaurants, bars, and tobacco shops in coastal zones based on availability of sufficient data which covers a period of 20 years (1999 to 2019). Temperature increase is the major climate change variability that was considered to affect tourism demand and supply. From the observed coastal regions, the temperature increase varies from 0.32°C to 1.12°C, and 1.78°C for the non-coastal region (Valle d' Aosta).

From collected data, tourism elements include:

From Demand Side

- Night Spent at Tourist Accommodation (NSTA)
- Total International Receipt (TIR) in tourism
- Total International Expenditure (TIE) in tourism

From Supply Side

- Number of Establishment (NE)
- Number of Beds (NB)
- Number of Accommodation and Restaurants (NAR)
- Number of Persons Employed in Accommodation and Restaurants (NPEAR)
- Wages of Employees in Accommodation and Restaurants (WEAR)
- Number of Bars and Tobacco Shops (NBT)
- Number of Persons Employed in Bars and Tobacco Shops (NPEBT)
- Wages of Employee in Bars ad Tobacco Shops (WEBT)

For Investment in Tourism

- Gross Fixed Capital Formation (GFCF) in Accommodation, Restaurant, Wholesale and Retail Trades, and Transportation

From expert view, tourism operation element exposed to temperature increase include:

- Cooling and Heating systems (CHS)

Coastal Regions (Liguria, Abruzzo, Campania, Calabria, Sicilia, and Sardegna)											
Climate Variable	NSTA	NE	NB	NAR	NPEAR	WEAR	NBT	NPEBT	WEBT	< CS	GFCF
Temperature (*Confidence Level >90%*)	Medium (positive)	Extreme (negative)	Extreme (positive)	Extreme (positive)	Extreme (negative)	Low (positive)	Low (negative)	Extreme (negative)	Extreme (negative)	Extreme (negative)	Low (positive)
Non-Coastal Region (Valle d' Aosta)											
Climate Variable	NSTA	NE	NB	NAR	NPEAR	WEAR	NBT	NPEBT	WEBT	< HS	GFCF
Temperature (*Confidence Level >90%*)	Medium (positive)	Low (positive)	Medium (positive)	Low (positive)	Low (positive)	High (positive)	Low (negative)	Low (positive)	Low (positive)	Medium (positive)	Low (positive)

Table 11.0: Risk Impact of Temperature Increase on Tourism Demand and Supply, investment and Energy Consumption in Cooling and Heating Systemin Coastal Regions of Italy, Comparing with Non-Coastal Regions (Valle d' Aosta) of Italy.

Climate Variable	NSTA	TIR	TIE	NE	NB	NAR	NPEAR	WEAR
Temperature (*Confidence Level >90%*)	Medium (positive)	Medium (positive)	High (positive)	Medium (positive)	Medium (positive)	Low (positive)	Medium (positive)	Medium (positive)
Climate Variable	NBT	NPEBT	WEBT	GFCF	<CS/HS			
Temperature (*Confidence Level >90%*)	Low (negative)	Low (negative)	Low (negative)	Medium (positive)	Medium (negative)			

Table 12.0: Risk Impact of Temperature Increase on Tourism Demand and Supply, investment and Energy Consumption in Cooling and Heating Systemin Italy at National Level

Coastal Regions						
Climate Variable	NE	NPEAR	NBT	NPEBT	WEBT	CS
Temperature (*Confidence Level >90%*)	Moderate	Moderate	Low	Low	Low	High
Non-Coastal Region						
Climate Variable	NBT	HS				
Temperature (*Confidence Level >90%*)	Low	Moderate				
National Level – Italy						
Climate Variable	NBT	NPEBT	WEBT	CS/HS		
Temperature (*Confidence Level >90%*)	Low	Low	Low	Moderate		

Table 13.0: Level of Vulnerability of Tourism Demand and Supply to Temperature Increase at National Level (Italy) and Regional Level (Coastal and Non-Coastal).

Considering the negative influence of temperature changes as risk impact to climate change, Number of Establishments (NE) in Hotels which include holiday and other short-stay accommodation; camping ground, recreational vehicle parks and trailer parks, Number of Persons Employed in Accommodation and Restaurants (NPEAR), Number of Persons Employed in Bars and Tobacco Shops (NPEBT), Wages of Employees in Bars and Tobacco Shops (WEBT), and <CS (Cooling System) have risk at extreme level while Number of Bars and Tobacco Shops (NBT) has risk at low level in the coastal region (Table 10.0). In the non-coastal region, NBT has low risk to temperature changes respectively (Table 10.0). At the national level, NBT, NPEBT and WEBT have low risk while <CS/HS has medium risk to temperature changes (Table 12.0).

The vulnerability assessment (Table 13.0) shows that in the coastal region of Italy, CS is highly vulnerable, NE and NPEAR are moderately vulnerable while NBT, NPEBT and WEBT have low vulnerability to temperature changes.

6.0 Discussions

6.1 Climate Change Impact on Tourism Demand and Supply

Climate change possesses a threat to tourism supply and demand. Findings from this research thesis shows that climate change has a positive and negative impact as well as direct and indirect impact in tourism demand and supply in the coastal zones of Italy and on Italy as a coastal country. Though in the non-coastal region and at the national level, findings show that climate change is mostly impacting tourism demand and supply in a positive way. With an observed average temperature increase of 0.8°C and 1.78°C in the coastal and non-coastal regions of Italy respectively. Climate change impacts positively to the demand side of tourism through the creating an enabling comfort for the inflow of tourist but has an opposite impact on the tourism supply at the regional level, where number of establishments (hotels) is impacted but in a negative way. In the other hand, number of bed places is impacted in a positive way. This suggests that rather than building more establishments (hotel) for tourist, existing residential buildings are acquired by new actors in the tourism industry and are used to provide bed places for tourist overnight stay at a reduced price (Mikulic et al, 2021; Cardona et al, 2021). This finding is also evident in the non-coastal region as temperature begins to warm up the cold region, it creates a conducive atmosphere that attracts tourism demand and positively impact tourism supply be increasing more bed places for tourist overnight stay. On specific tourism industries like the accommodation and restaurants, climate change impact positively on the number of restaurants and accommodation which is in line with the increase in number of bed places in acquired residential buildings, because of the cost to build and operate new establishment which is capital intensive and land use policy. As the temperature in the coastal zone continues to support tourism demand (tourist inflow and overnight stay), the demand for food also increases thereby creating more opportunity in the food supply. This is in line with Arabadzhyan et al (2021) who reported that restaurants are directly influenced by climate change, and may have severe consequences, especially for small and medium businesses with reduced access to financial market, which effect can be more pronounced in the long run, if the area is characterized by high degree of competition, which is often the case of coastal areas. This finding is in line with Kaarina et al (2018) who reported that the accommodation and restaurants benefit the most from the changes in weather fluctuation, but small scale suffer the most. Also, in line with Eva et al (2015), who reported observed failed recruitment (too many seasonal workers, too early in the season) which was a contributing factor to increase loss of revenue, and Day et al (2021) who reported that impact of changing weather will impact workers, there is a negative impact on the number of persons employed in the accommodation and restaurant industry which suggest that temperature annual seasonality has a negative effect in the persons employed in the accommodation and restaurants: as the temperature in the year begins to increase and support the inflow of tourist, operators in the accommodation and restaurants begins to create opening for new employment for the season, but as the temperature in the year begins to decrease, operators begin to lay off workers. This finding also supports Michelle and Judith (2013) who reported an increase in the population of the locals employed by the resort and guesthouse which accommodated tourist. In respective of how evident climate change has impacted the accommodation and restaurant, findings show that it has no impact on the wages of employees in the accommodation and restaurants at the regional level. In the non-coastal region, findings show that climate change has a positive impact on the wages of employees in the accommodation and restaurant. Also, other specific tourism operators like the bars and tobacco shops, findings shows that there is no impact of climate change on the number of bars and tobacco shops at the national and coastal regions of Italy, but findings show that climate change has a negative effect on the number of persons employed and the wages of persons employed in bars and tobacco shops at the national and coastal regions of Italy. This suggests that the temperature increase do not support the consumption of alcohol and tobacco despite the increase in tourist inflow. In the non-coastal region, findings show that there is no impact of climate change in the number of bars and tobacco shops, the number of persons employed in bars and tobacco shops and the wages of employees in bars and tobacco shops.

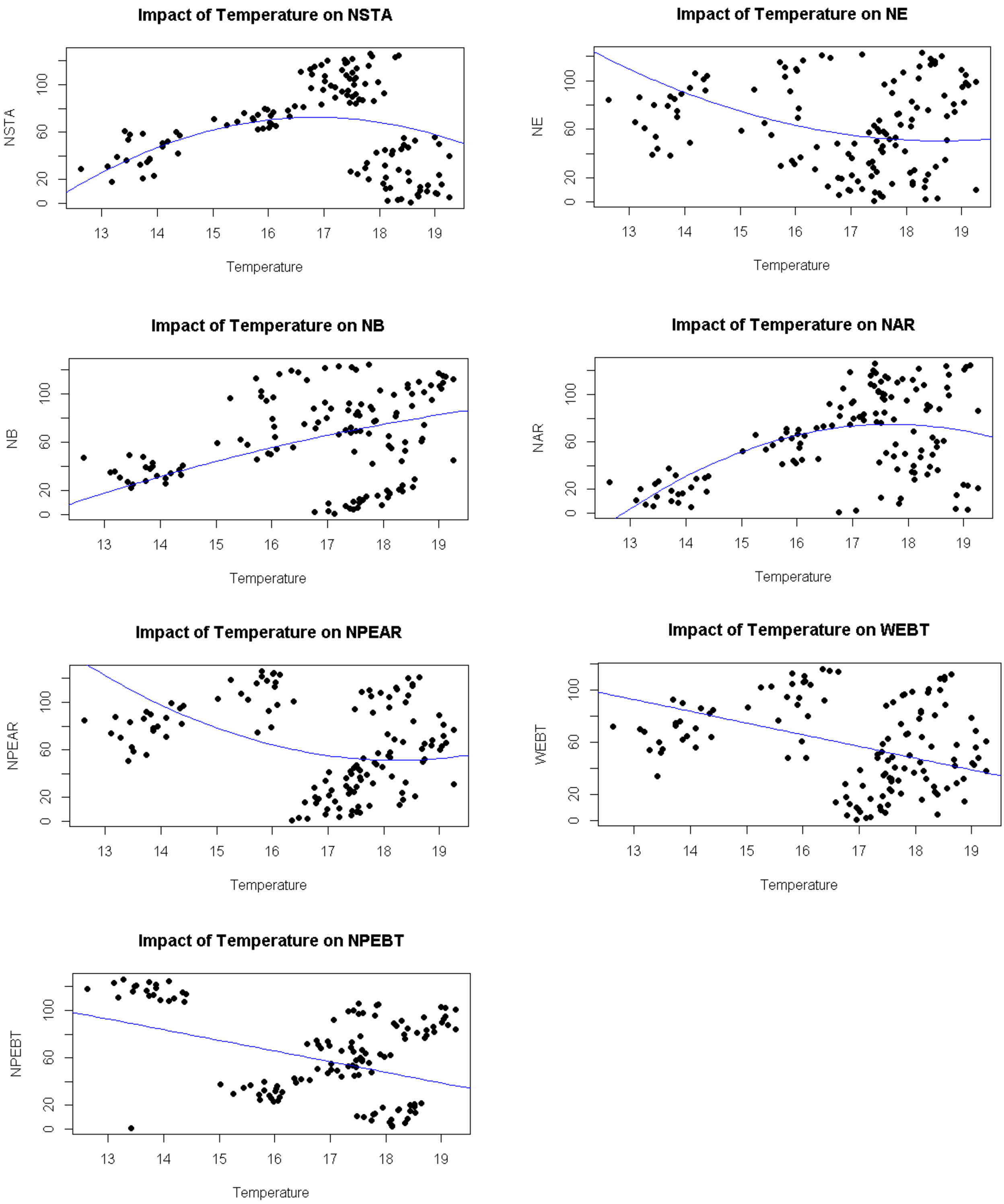

Figure 5.0: Observed patterns of temperature increase on tourism demand and supply in coastal zone of Italy.

6.2 Explaining the Observed Pattern of Temperature Impact on Tourism Demand and Supply in Coastal Zones of Italy

To give explanation to the pattern of the impact of temperature on tourism demand and supply in coastal zones of Italy, a quadratic regression model was fitted to the scatter plot of temperature variable (Temp) to the x-axis and tourism supply and demand variables which shows p-value as significant in Table 6.0 to the y-axis. The quadratic regression model:

$$y = \beta_0 + \beta_1 X + \beta_2 X^2 + \epsilon$$

y is tourism supply and demand variables ($Tourism\_Var$), which are the predicted value of the response variable (y) for any given value of the independent variable (X).

β_0 is the intercept, the predicted value of y when the X is 0.

β_1 and β_2 are the regression coefficient – how much we expect to change as X increases.

X is temperature ($Temp$) which is the explanatory variable (the variable we expect is influencing y).

ϵ is the error of the estimate, or how much variation there is in our estimate of the regression coefficient.

The following R programming syntax were used to code the quadratic regression model.

Creating a new variable for temperature

$Temp2 = Temp\text{^}2$

Fitting a quadratic regression model

$Quadratic_{model} < -plm(Tourism_{Var} \sim Temp + Temp2)$

Creating list of predicted tourism supply and demand variable levels using quadratic model

$Tempvalues < -seq(0,60,0.1)$

$$Predict_{Tourism_{Var}} < -predict(Quadratic_{model}, list(Temp = Tempvalues, Temp2 = Tempvalues \wedge 2))$$

Creating a scatterplot of original data value

$plot(Temp, Tourism_{Var})$

Adding predicted lines based on the quadratic regression model.

$lines(Temp, Predict_{Tourism_{Var}}, col = "blue")$

Evidence suggests that temperature increase behaves differently with tourism demand and tourism supply in the coastal zone (Figure 5.0). The shape of the model suggests temperature has a limit of supporting inflow of tourist and their overnight stay (NSTA). This insight is in line with Aylen (2014) who state that there is clear evidence that warmer temperature encouraged visit, but only up to a threshold level around 21°C, and according to Leal Filho (2022), further increase makes coastal tourism and inland tourism very uncomfortable, as high temperature are incompatible with outdoor activities. This has an opposite effect on the tourism accommodation establishment (NE), which also indirectly affects the employment rate (NPEAR) and wages of employees (WEAR) in tourism accommodation establishment. But the discrepancy between the opposite effect of tourism accommodation establishment (NE) and the positive effect of number of beds (NB) by temperature increase is in line with Cardona et al (2021) who reported that the growth in tourism demand has been absorbed by the hotel sector, and tourist used homes have an adjustment tool between rapidly growing demand and hotel supply that is evolving more slowly. Because temperature supports tourist arrivals, as the summer ends and the arrival of tourists moderates or stops, the hotel sector recovers its market share of the detriment of tourist rentals. This may have a greater effect on tourist rentals in established hotels than other types of accommodation that provides bed places, as homes are being converted into rentals due to increased tourist population (Mikulic et al, 2021). This other type of accommodation absorbed excess demand that hotels could not meet, and when this excess disappeared, their occupancy levels dropped greatly (Cardona et al ,2021). Evidence also suggests that temperature increase does not support the growth of the bar and tobacco shop sector as wages (WEBT) and employee rate (NPEBT) demonstrate opposite effect with increase in temperature.

6.3 Climate Change Impact on Tourism Operators

The economic consequences of climate change (temperature increase) impact on tourism supply (increase in accommodation, bed places and restaurants) suggested by expert judgment is the demand and prolonged operational time of cooling system in accommodation and bed places, and restaurants, to bring comfort to tourist which is in line with Hynn-Gyn (2021) and Pablo-Romero et al (2019) who respectively reported the impact of climate change on electricity consumption; stating that the accommodation and restaurants falls among those impacted by climate change in energy consumption, and that an increase in temperature produces a greater demand for cooling energy. This will lead to increase in maintenance cost of cooling system, investment in high-capacity cooling system in cases of total breakdown or upgrading of old cooling systems, increase in energy (electricity and gas) consumption to operate cooling systems, and increase in energy bills incurred by operation of cooling systems. This circumstance can lead to financial losses because of lack of access to capital and resources to recover from climate impact (Chanrith, 2020). These consequences could produce supply shocks resulting in price volatility (European Central Bank, 2021; Benjamin, February 2022). This finding is in line with Eva et al (2015) who reported that cost occurred through an increase in maintenance cost and energy consumption and if these are not well budgeted beforehand, the cost may result in cashflow problems among small businesses, which typically have less financial reserve for unexpected expenses.

6.4 Relationship Between Temperature Change, Tourism Demand, Supply, and Investment in Italy.

Temperature is a major influence in tourism development in coastal areas especially in Italy, but this has been proven only on tourism demand using tourism inflow. However, the extent temperature affects the tourism sector; demand, supply, investment and on specific tourism businesses is explained using correlogram (Figure 3.0). The result explains that, at the regional level, it will be unrealistic to define the impact of climate change at specific tourism businesses, but how climate change affects tourism demand and supply can possibly be determined on a general scale at the national and regional level. In the same way, climate change influence on investment is feasible at the national level but has no influence at the regional level. There is also a strong feasible relationship between tourism demand and supply at the national level but a weak relationship at the regional level. At the national level, the effect of climate change on tourism supply can not be explained but there is a clear explanation on the effect of climate change and tourism demand on tourism supply because tourism demand which is lined to the temperature comfortability influences the supply side of tourism. This claim is in line with Nojarov (2021) who states that climate change has different manifestations at regional level because of atmospheric circulation – were warming because of temperature increase leads to a change in the extent of Hadley cell, and its northern boundary moves northward in the northern hemisphere especially in the summer and autumn.

6.5 Risk Impact, Vulnerability and Adaptation Measures

The effect of climate change on bars and tobacco shops both at the national and regional level shows negative risk impact, but because of its insignificant consequences as referred to Table 4.0 - consequence criteria adopted from AS5334-2013 climate change adaptation for settlement and infrastructure, there is no infrastructure damage, little financial loss or income in operating expenses and no effect on broader economy, which do not require any change in services. Hence, no change in adaptation is required. At the coastal region where the risk impact of climate change is extremely negative on the number of persons employed in accommodation and restaurants, number of establishments in Hotels which include holiday and other short-stay accommodation; camping ground, recreational vehicle parks and trailer parks and Cooling Systems, extensive infrastructure damage requiring major repairs, early renewal of infrastructure by 50 – 90% before the tourism season, major loss of infrastructure service, severe disruption of employees due to major financial loss all which can lead to serious effect on the local economy are evident. This explains major loss in adaptive capacity, renewal or repair would need new innovations, or design and management responsibility improvement are required to improve adaptive capacity to climate change.

The risk level (High) requires an immediate government (regional or national), institutions or relevant agencies intervention through policies reforms that can support new establishments to be productive and make job opportunities available to people in the tourism sector. Such policies should provide provisions for supporting tourism operators in coastal zones and providing adequate insurance for them in cases of climate change impact. This policy will also include support for transition from non-renewable energy for cooling systems to renewable energy and the cost of transition should be subsidized by the government.

6.5.1 Monetary Policy for Climate Change Resilience for Coastal Tourism Operator.

Adaptation policies for climate change resilience for tourism operators in coastal region of Italy is an adequate measure by which tourism operators with low financial strength can endure in this era of rising temperature which has numerous social, economic, and financial consequences. During the supply of comfort by tourism operators to tourist through prolonged cooling time by cooling systems during the summer and autum, there will be increase in emission of carbon by combustion of gas and electricity (gas generated) (Carrilo et al, 2022). This may lead to smaller tourism operators experiencing financial losses. According to Leal Filho (2022), the increase temperature makes coastal tourism and inland tourism very uncomfortable with outdoor activities in beaches and cities. This can negatively have impact on tourism sector through prolonged summer period, hence extending time were hotels and other facilities are open. Therefore, adaptation to climate change, which is a long-lasting process, requires a strategic approach. UNWTO (2020) report states that the major sub sector that has led tourism investment from 2015 to 2019 are with the construction as the main driver for around 57% of total Greenfield investment. The trend in accommodation is around sustainability where multinational companies are investing in green, clean energy matrix of their operations. It added in its report that investors are paying increasing attention to the social and environmental footprint of the projects they assess in tourism. They seem willing to prioritize development that lifts communities and preserves ecosystems if financial sustainability is also considered. According to UNWTO (2018, 2019, and 2020) report, Italy spent 21 million USD, 18 million USD, and 32 million USD in capital investment in tourism respectively which corresponds to Leal Filho (2020).

The Sustainable Finance Strategy published on 6 July 2021 by the European Union provides a roadmap with a new action to increase private investment in sustainable projects and activities to support the European Grean Deal. This policy supports the flow of private finance towards sustainable economic activities and makes the transition to carbon neutral economy by 2050 possible.

The action below are the guidelines to achieve the objectives of this policy.

a. Financing the transition of the real economy towards sustainability.
b. Towards a more inclusive sustainable finance framework
c. Improving the financial sectors resilience and contribution to sustainability
d. Fostering global ambitions

European Union (6 July 2021).

The first and second action is strongly applicable to tourism operators. The following further actions are required for their implementation.

a. Financing the transition of the real economy towards sustainability.
    - Support financing certain economic activities contributing to reducing greenhouse emission.
    - Consider options for a possible extension of the EU Taxonomy framework to recognize transition efforts.
    - Include additional sustainable activities in the EU Taxonomy
    - Extend sustainable finance standards and labels that support financing the transition of sustainability and phased transition efforts.
b. Towards a more inclusive sustainable finance framework
    - Empower retail investors and SMEs to access sustainable finance opportunities.
    - Explore how to leverage the opportunities that digital technologies offer for sustainable finance.
    - Work towards greater protection from climate and environmental risks through increasing insurance coverage
    - Publish a report on social taxonomy.
    - Work on green budgeting and risk-sharing mechanism.

European Union (6 July 2021).

6.6 Limitation

This research is limited to secondary data sourced from Eurostat, OECD and expert judgement. Attempts were made to collect data based on operators/owners of tourism establishments (Hotels, restaurants, guesthouse, resort areas, etc) through online and physical survey questions on their perception on climate change and how it is affecting their operation with the cost involved in their effort to adapt to climate change situations, but there were no responses.

6.7 Recommendation

To improve this research support should be made to collect real data from tourism operators on how they perceive climate change, its effects on their establishments, its effect on their investment, budgeting, and cash flow, also how they have invested in adaptation to climate change effect. Further studies on how climate change effect tourism supply across tourist coastal and non-coastal countries in the European Union will be considered.

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APPENDIX

1.0 Regression Tables for Temperature with Time for the Six Coastal Regions and the control (Non-Coastal) Region

1.1 Liguria Region

```
> summary(lm((Liguria_Temp$ANN)~YEAR))

Call:
lm(formula = (Liguria_Temp$ANN) ~ YEAR)

Residuals:
     Min       1Q   Median       3Q      Max 
-1.12923 -0.09388  0.06134  0.25007  0.59204 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)  
(Intercept) -61.26337   29.37515  -2.086   0.0507 .
YEAR          0.03732    0.01462   2.553   0.0194 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.4057 on 19 degrees of freedom
Multiple R-squared:  0.2554,	Adjusted R-squared:  0.2162 
F-statistic: 6.516 on 1 and 19 DF,  p-value: 0.01945
```

1.2 Abruzzo Region

```
> summary(lm((Abruzzo_Temp$ANN)~YEAR))

Call:
lm(formula = (Abruzzo_Temp$ANN) ~ YEAR)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.54612 -0.15602 -0.00617  0.11697  0.50058 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)   
(Intercept) -49.55193   20.46054  -2.422  0.02561 * 
YEAR          0.03335    0.01018   3.275  0.00399 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2826 on 19 degrees of freedom
Multiple R-squared:  0.3608,	Adjusted R-squared:  0.3271 
F-statistic: 10.72 on 1 and 19 DF,  p-value: 0.003986
```

1.3 Campania Region

```
> summary(lm((Campania_Temp$ANN)~YEAR))

Call:
lm(formula = (Campania_Temp$ANN) ~ YEAR)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.80724 -0.23310  0.04762  0.23305  0.60105 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)  
(Intercept) -32.57919   26.77953  -1.217   0.2387  
YEAR          0.02414    0.01333   1.811   0.0859 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3699 on 19 degrees of freedom
Multiple R-squared:  0.1472,    Adjusted R-squared:  0.1024 
F-statistic:  3.28 on 1 and 19 DF,  p-value: 0.08595
```

1.4 Calabria Region

```
> summary(lm((Calabria_Temp$ANN)~YEAR))

Call:
lm(formula = (Calabria_Temp$ANN) ~ YEAR)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.61015 -0.29635  0.07054  0.26203  0.49066 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)  
(Intercept) -38.35096   24.69149  -1.553   0.1369  
YEAR          0.02770    0.01229   2.254   0.0362 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.341 on 19 degrees of freedom
Multiple R-squared:  0.211,     Adjusted R-squared:  0.1694 
F-statistic:  5.08 on 1 and 19 DF,  p-value: 0.0362
```

1.5 Sicilia Region

```
> summary(lm((Sicilia_Temp$ANN)~YEAR))

Call:
lm(formula = (Sicilia_Temp$ANN) ~ YEAR)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.59504 -0.25630  0.05118  0.21008  0.49244 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -19.49918   22.84882  -0.853    0.404
YEAR          0.01874    0.01137   1.648    0.116

Residual standard error: 0.3156 on 19 degrees of freedom
Multiple R-squared:  0.125,	Adjusted R-squared:  0.07898 
F-statistic: 2.715 on 1 and 19 DF,  p-value: 0.1158

> summary(lm((Sardegna_Temp$ANN)~YEAR))
```

1.6 Sardegna Region

```
> summary(lm((Sardegna_Temp$ANN)~YEAR))

Call:
lm(formula = (Sardegna_Temp$ANN) ~ YEAR)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.58607 -0.13216  0.03547  0.12238  0.74311 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept) -58.507563  19.359595  -3.022 0.007009 ** 
YEAR          0.038455   0.009636   3.991 0.000783 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.2674 on 19 degrees of freedom
Multiple R-squared:  0.456,	Adjusted R-squared:  0.4273 
F-statistic: 15.92 on 1 and 19 DF,  p-value: 0.0007829
```

1.7 Valle d' Aosta Region

```
> summary(lm((Valle_Aosta_Temp$ANN)~YEAR))

Call:
lm(formula = (Valle_Aosta_Temp$ANN) ~ YEAR)

Residuals:
     Min       1Q   Median       3Q      Max 
-1.55913 -0.17087  0.05304  0.29391  0.80783 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)  
(Intercept) -94.44191   41.05305  -2.300   0.0329 *
YEAR          0.04913    0.02043   2.404   0.0266 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.567 on 19 degrees of freedom
Multiple R-squared:  0.2333,	Adjusted R-squared:  0.1929 
F-statistic:  5.78 on 1 and 19 DF,  p-value: 0.02657
```

1.8 Italy

```
> summary(lm(TEMP_Italy~YEAR_IT))

Call:
lm(formula = TEMP_Italy ~ YEAR_IT)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.84535 -0.10381  0.06367  0.18832  0.38731 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)  
(Intercept) -129.37528   58.69468  -2.204   0.0521 .
YEAR_IT        0.07133    0.02915   2.447   0.0344 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3486 on 10 degrees of freedom
Multiple R-squared:  0.3745,	Adjusted R-squared:  0.312 
F-statistic: 5.987 on 1 and 10 DF,  p-value: 0.03444

> cor(YEAR_IT,TEMP_Italy)
[1] 0.6119688
```

2.0 Panel Data Analysis

2.1 Validating the assumption that Temperature has influence on Night spent at tourist accommodation (NSTA) in coastal zone of Italy.

```
> phtest(fixed_NSTA,random_NSTA) #Hausman test

        Hausman Test

data:  NSTA_Coast1 ~ Temp_Coast
chisq = 2.5553, df = 1, p-value = 0.1099
alternative hypothesis: one model is inconsistent
```

```
> # Random effect analysis
> random_analysis_NSTA <- plm(NSTA_Coast1 ~ Temp_Coast, data=Coastal_Data,
+                 index=("Year"), model="random")
> summary(random_analysis_NSTA)
Oneway (individual) effect Random Effect Model
   (Swamy-Arora's transformation)

Call:
plm(formula = NSTA_Coast1 ~ Temp_Coast, data = Coastal_Data,
    model = "random", index = ("Year"))

Balanced Panel: n = 21, T = 6, N = 126

Effects:
                  var std.dev share
idiosyncratic  166.08   12.89 0.116
individual    1267.95   35.61 0.884
theta: 0.8538

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-67.67275  -6.28898   0.69428   6.41991  57.62636

Coefficients:
            Estimate Std. Error z-value Pr(>|z|)
(Intercept) -31.8565    39.6541 -0.8034  0.42177
Temp_Coast    5.6483     2.3018  2.4539  0.01413 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    21847
Residual Sum of Squares: 20835
R-Squared:      0.046313
Adj. R-Squared: 0.038622
Chisq: 6.02163 on 1 DF, p-value: 0.014132
```

2.2 Validating the assumption that Temperature has influence on number of establishments (NE) in coastal zones of Italy.

```
> phtest(fixed_NE,random_NE) #Hausman test

        Hausman Test

data:  NE_Coast1 ~ Temp_Coast
chisq = 11.156, df = 1, p-value = 0.0008377
alternative hypothesis: one model is inconsistent
```

```
> # Fixed effect analysis
> fixed_analysis_NE <- plm(NE_Coast1 ~ Temp_Coast, data=Coastal_Data,
+                          index=("Year"), model="within")
> summary(fixed_analysis_NE)
Oneway (individual) effect Within Model

Call:
plm(formula = NE_Coast1 ~ Temp_Coast, data = Coastal_Data, model = "within",
    index = ("Year"))

Balanced Panel: n = 21, T = 6, N = 126

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-80.80811  -7.85603  -0.43317   9.99606  61.61286

Coefficients:
           Estimate Std. Error t-value  Pr(>|t|)
Temp_Coast -19.7982     4.3353 -4.5667 1.365e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    57430
Residual Sum of Squares: 47837
R-Squared:      0.16703
Adj. R-Squared: -0.00116
F-statistic: 20.8552 on 1 and 104 DF, p-value: 1.3648e-05
```

2.3 Validating the assumption that Temperature has influence on number of Beds (NB) in coastal zones of Italy.

```
> phtest(fixed_NB,random_NB) #Hausman test

        Hausman Test

data:  NB_Coast1 ~ Temp_Coast
chisq = 3.7594, df = 1, p-value = 0.05251
alternative hypothesis: one model is inconsistent
```

```
> # Random effect analysis
> random_analysis_NB <- plm(NB_Coast1 ~ Temp_Coast, data=Coastal_Data,
+                           index=("Year"), model="random")
> summary(random_analysis_NB)
Oneway (individual) effect Random Effect Model
   (Swamy-Arora's transformation)

Call:
plm(formula = NB_Coast1 ~ Temp_Coast, data = Coastal_Data, model = "random",
    index = ("Year"))

Balanced Panel: n = 21, T = 6, N = 126

Effects:
                 var std.dev share
idiosyncratic 421.79   20.54 0.344
individual    803.74   28.35 0.656
theta: 0.7164

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-48.09019 -12.81103  -0.45688   9.68724  73.64121

Coefficients:
             Estimate Std. Error z-value  Pr(>|z|)
(Intercept) -114.6009    49.1598 -2.3312 0.0197433 *
Temp_Coast    10.5054     2.8862  3.6399 0.0002728 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    59144
Residual Sum of Squares: 53435
R-Squared:      0.096531
Adj. R-Squared: 0.089245
Chisq: 13.2488 on 1 DF, p-value: 0.00027276
```

2.4 Validating the assumption that Temperature has influence on number of accommodation and restaurants (NAR) in coastal zones of Italy.

```
> phtest(fixed_NAR,random_NAR) #Hausman test

        Hausman Test

data:  NAR_Coast1 ~ Temp_Coast
chisq = 0.083075, df = 1, p-value = 0.7732
alternative hypothesis: one model is inconsistent
```

```
> # Random effect analysis
> random_analysis_NAR <- plm(NAR_Coast1 ~ Temp_Coast, data=Coastal_Data,
+                            index=("Year"), model="random")
> summary(random_analysis_NAR)
Oneway (individual) effect Random Effect Model
   (Swamy-Arora's transformation)

Call:
plm(formula = NAR_Coast1 ~ Temp_Coast, data = Coastal_Data, model = "random",
    index = ("Year"))

Balanced Panel: n = 21, T = 6, N = 126

Effects:
                 var std.dev share
idiosyncratic 702.58   26.51 0.651
individual    377.24   19.42 0.349
theta: 0.5133

Residuals:
    Min.  1st Qu.   Median  3rd Qu.     Max.
-80.2191 -11.4657   3.1793  11.1959  56.1337

Coefficients:
             Estimate Std. Error z-value  Pr(>|z|)
(Intercept) -102.3412    43.8272 -2.3351 0.0195377 *
Temp_Coast     9.8234     2.5802  3.8072 0.0001405 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    96585
Residual Sum of Squares: 86476
R-Squared:      0.10466
Adj. R-Squared: 0.097439
Chisq: 14.4948 on 1 DF, p-value: 0.00014054
```

2.5 Validating the assumption that Temperature has influence on Wages of employees in accommodation and restaurant (WEAR) in coastal zones of Italy.

```
> phtest(fixed_WEAR,random_WEAR) #Hausman test

        Hausman Test

data:  WEAR_Coast1 ~ Temp_Coast
chisq = 1.0832, df = 1, p-value = 0.298
alternative hypothesis: one model is inconsistent
```

```
> # Random effect analysis
> random_analysis_WEAR <- plm(WEAR_Coast1 ~ Temp_Coast, data=Coastal_Data,
+                         index=("Year"), model="random")
> summary(random_analysis_WEAR)
Oneway (individual) effect Random Effect Model
   (Swamy-Arora's transformation)

Call:
plm(formula = WEAR_Coast1 ~ Temp_Coast, data = Coastal_Data,
    model = "random", index = ("Year"))

Balanced Panel: n = 21, T = 6, N = 126

Effects:
                 var std.dev share
idiosyncratic 546.64   23.38 0.397
individual    829.77   28.81 0.603
theta: 0.6855

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-72.74223 -13.10735   0.89106  13.80094  87.51051

Coefficients:
            Estimate Std. Error z-value Pr(>|z|)
(Intercept) 49.09103   52.26580  0.9393   0.3476
Temp_Coast   0.81025    3.07093  0.2638   0.7919

Total Sum of Squares:    67867
Residual Sum of Squares: 67829
R-Squared:      0.00056109
Adj. R-Squared: -0.0074989
Chisq: 0.0696136 on 1 DF, p-value: 0.7919
```

2.6 Validating the assumption that Temperature has influence on Number of persons employed in accommodation and restaurant (NPEAR) in coastal zones of Italy.

```
> phtest(fixed_NPEAR,random_NPEAR) #Hausman test

        Hausman Test

data:  NPEAR_Coast1 ~ Temp_Coast
chisq = 3.5155, df = 1, p-value = 0.0608
alternative hypothesis: one model is inconsistent
```

```
> # Random effect analysis
> random_analysis_NPEAR <- plm(NPEAR_Coast1 ~ Temp_Coast, data=Coastal_Data,
+                              index=("Year"), model="random")
> summary(random_analysis_NPEAR)
Oneway (individual) effect Random Effect Model
   (Swamy-Arora's transformation)

Call:
plm(formula = NPEAR_Coast1 ~ Temp_Coast, data = Coastal_Data,
    model = "random", index = ("Year"))

Balanced Panel: n = 21, T = 6, N = 126

Effects:
                  var std.dev share
idiosyncratic  263.42   16.23 0.196
individual    1082.66   32.90 0.804
theta: 0.8026

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-51.76486  -8.86789  -0.52275   9.86967  59.00548

Coefficients:
             Estimate Std. Error z-value  Pr(>|z|)
(Intercept) 245.3629    45.6677  5.3728 7.753e-08 ***
Temp_Coast  -10.7724     2.6694 -4.0356 5.447e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    37666
Residual Sum of Squares: 33293
R-Squared:      0.11609
Adj. R-Squared: 0.10896
Chisq: 16.2858 on 1 DF, p-value: 5.4471e-05
```

2.7 Validating the assumption that Temperature has influence on Number of bars and tobacco shop (NBT) in coastal zones of Italy.

```
> phtest(fixed_NBT,random_NBT) #Hausman test

        Hausman Test

data:  NBT_Coast1 ~ Temp_Coast
chisq = 0.0020532, df = 1, p-value = 0.9639
alternative hypothesis: one model is inconsistent
```

```
> # Random effect analysis
> random_analysis_NBT <- plm(NBT_Coast1 ~ Temp_Coast, data=Coastal_Data,
+                            index=("Year"), model="random")
> summary(random_analysis_NBT)
Oneway (individual) effect Random Effect Model
   (Swamy-Arora's transformation)

Call:
plm(formula = NBT_Coast1 ~ Temp_Coast, data = Coastal_Data, model = "random",
    index = ("Year"))

Balanced Panel: n = 21, T = 6, N = 126

Effects:
                 var std.dev share
idiosyncratic 553.53   23.53 0.426
individual    745.97   27.31 0.574
theta: 0.6682

Residuals:
   Min. 1st Qu.  Median 3rd Qu.    Max.
-76.620 -12.939  -1.245  12.951  76.908

Coefficients:
            Estimate Std. Error z-value Pr(>|z|)
(Intercept) 139.9815    50.7241  2.7597 0.005786 **
Temp_Coast   -4.6097     2.9814 -1.5462 0.122061
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    69398
Residual Sum of Squares: 68085
R-Squared:      0.018915
Adj. R-Squared: 0.011003
Chisq: 2.39068 on 1 DF, p-value: 0.12206
```

2.8 Validating the assumption that Temperature has influence on wages of employee in bars and tobacco shop (WEBT) in coastal zones of Italy.

```
> phtest(fixed_WEBT,random_WEBT) #Hausman test

        Hausman Test

data:  WEBT_Coast1 ~ Temp_Coast
chisq = 5.8442, df = 1, p-value = 0.01563
alternative hypothesis: one model is inconsistent
```

```
> # Fixed effect analysis
> fixed_analysis_WEBT <- plm(WEBT_Coast1 ~ Temp_Coast, data=Coastal_Data,
+                            index=("Year"), model="within")
> summary(fixed_analysis_WEBT)
Oneway (individual) effect Within Model

Call:
plm(formula = WEBT_Coast1 ~ Temp_Coast, data = Coastal_Data,
    model = "within", index = ("Year"))

Balanced Panel: n = 21, T = 6, N = 126

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-57.62965  -9.83955   0.87241  11.71050  42.40029

Coefficients:
           Estimate Std. Error t-value  Pr(>|t|)
Temp_Coast -16.5731     4.2035 -3.9427 0.0001464 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    51695
Residual Sum of Squares: 44973
R-Squared:      0.13003
Adj. R-Squared: -0.045634
F-statistic: 15.5447 on 1 and 104 DF, p-value: 0.00014636
>
```

2.9 Validating the assumption that Temperature has influence on number of persons employed in bars and tobacco shop (NPEBT) in coastal zones of Italy.

```
> phtest(fixed_NPEBT,random_NPEBT) #Hausman test

        Hausman Test

data:  NPEBT_Coast1 ~ Temp_Coast
chisq = 0.25119, df = 1, p-value = 0.6162
alternative hypothesis: one model is inconsistent
```

```
> # Random effect analysis
> random_analysis_NPEBT <- plm(NPEBT_Coast1 ~ Temp_Coast, data=Coastal_Data,
+                              index=("Year"), model="random")
> summary(random_analysis_NPEBT)
Oneway (individual) effect Random Effect Model
   (Swamy-Arora's transformation)

Call:
plm(formula = NPEBT_Coast1 ~ Temp_Coast, data = Coastal_Data,
    model = "random", index = ("Year"))

Balanced Panel: n = 21, T = 6, N = 126

Effects:
                  var std.dev share
idiosyncratic  246.07   15.69 0.195
individual    1014.96   31.86 0.805
theta: 0.8029

Residuals:
      Min.    1st Qu.     Median    3rd Qu.       Max.
-101.57148   -7.85279    0.60637    8.31687   38.11269

Coefficients:
            Estimate Std. Error z-value  Pr(>|z|)
(Intercept) 217.0488    43.6144  4.9765 6.473e-07 ***
Temp_Coast   -9.0953     2.5493 -3.5678   0.00036 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    33442
Residual Sum of Squares: 30329
R-Squared:      0.093097
Adj. R-Squared: 0.085783
Chisq: 12.7291 on 1 DF, p-value: 0.00036002
```

2.10 Validating the assumption that Temperature has influence on Investment using Gross Fixed Capital Formation (GFCF) in coastal zones of Italy.

```
> phtest(fixed_GFCF,random_GFCF) #Hausman test

        Hausman Test

data:  GFCF_Coast1 ~ Temp_Coast
chisq = 1.3054, df = 1, p-value = 0.2532
alternative hypothesis: one model is inconsistent
```

```
> # Random effect analysis
> random_analysis_GFCF <- plm(GFCF_Coast1 ~ Temp_Coast, data=Coastal_Data,
+                             index=("Year"), model="random")
> summary(random_analysis_GFCF)
Oneway (individual) effect Random Effect Model
   (Swamy-Arora's transformation)

Call:
plm(formula = GFCF_Coast1 ~ Temp_Coast, data = Coastal_Data,
    model = "random", index = ("Year"))

Balanced Panel: n = 21, T = 6, N = 126

Effects:
                 var std.dev share
idiosyncratic 563.07   23.73 0.411
individual    807.12   28.41 0.589
theta: 0.6773

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-78.04727 -17.04760   0.99793  16.15963  72.87514

Coefficients:
            Estimate Std. Error z-value Pr(>|z|)
(Intercept)  43.5488    52.2914  0.8328   0.4050
Temp_Coast    1.1442     3.0730  0.3723   0.7096

Total Sum of Squares:    70070
Residual Sum of Squares: 69992
R-Squared:      0.0011168
Adj. R-Squared: -0.0069387
Chisq: 0.138635 on 1 DF, p-value: 0.70964
```

3.0 Linear Regression Analysis for Non-Coastal Zone (Valle d' Aosta Region)

3.1 Validating the assumption that Temperature has influence on Night spent at tourist accommodation (NSTA) in non-coastal zone of Italy.

```
> summary(lm(NSTA_Va_nCoast1~Temp_Va_nCoast))

Call:
lm(formula = NSTA_Va_nCoast1 ~ Temp_Va_nCoast)

Residuals:
     Min       1Q   Median       3Q      Max 
-10.8661  -1.5930   0.4591   5.0297   7.2084 

Coefficients:
               Estimate Std. Error t value Pr(>|t|)  
(Intercept)     -11.199      8.231  -1.361   0.1896  
Temp_Va_nCoast    5.211      1.912   2.725   0.0134 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 5.398 on 19 degrees of freedom
Multiple R-squared:  0.281,	Adjusted R-squared:  0.2432 
F-statistic: 7.425 on 1 and 19 DF,  p-value: 0.01344
```

3.2 Validating the assumption that Temperature has influence on Number of Establishment (NE) in non-coastal zone of Italy.

```
> summary(lm(NE_Va_nCoast1~Temp_Va_nCoast))

Call:
lm(formula = NE_Va_nCoast1 ~ Temp_Va_nCoast)

Residuals:
    Min      1Q  Median      3Q     Max 
-9.2462 -5.4924  0.3838  5.2028  9.6017 

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)      7.9150     9.6811   0.818    0.424
Temp_Va_nCoast   0.7242     2.2492   0.322    0.751

Residual standard error: 6.349 on 19 degrees of freedom
Multiple R-squared:  0.005427,	Adjusted R-squared:  -0.04692 
F-statistic: 0.1037 on 1 and 19 DF,  p-value: 0.751
```

3.3 Validating the assumption that Temperature has influence on Number of Beds (NB) in non-coastal zone of Italy.

```
> summary(lm(NB_Va_nCoast1~Temp_Va_nCoast))

Call:
lm(formula = NB_Va_nCoast1 ~ Temp_Va_nCoast)

Residuals:
   Min     1Q Median     3Q    Max 
-9.950 -2.783  1.526  4.583  6.774 

Coefficients:
               Estimate Std. Error t value Pr(>|t|)  
(Intercept)      -7.462      8.713  -0.856   0.4025  
Temp_Va_nCoast    4.334      2.024   2.141   0.0455 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 5.714 on 19 degrees of freedom
Multiple R-squared:  0.1943,	Adjusted R-squared:  0.1519 
F-statistic: 4.583 on 1 and 19 DF,  p-value: 0.04547
```

3.4 Validating the assumption that Temperature has influence on Number of Accommodation and Restaurants (NAR) in non-coastal zone of Italy.

```
> summary(lm(NAR_Va_nCoast1~Temp_Va_nCoast))

Call:
lm(formula = NAR_Va_nCoast1 ~ Temp_Va_nCoast)

Residuals:
    Min      1Q  Median      3Q     Max 
-9.7206 -5.2372  0.1792  4.5098 10.3374 

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)      8.7544     9.6935   0.903    0.378
Temp_Va_nCoast   0.5271     2.2521   0.234    0.817

Residual standard error: 6.357 on 19 degrees of freedom
Multiple R-squared:  0.002875,	Adjusted R-squared:  -0.0496 
F-statistic: 0.05479 on 1 and 19 DF,  p-value: 0.8174
```

3.5 Validating the assumption that Temperature has influence on Wages of Employees in Accommodation and Restaurants (WEAR) in non-coastal zone of Italy.

```
> summary(lm(WEAR_Va_nCoast1~Temp_Va_nCoast))

Call:
lm(formula = WEAR_Va_nCoast1 ~ Temp_Va_nCoast)

Residuals:
    Min      1Q  Median      3Q     Max 
-12.497  -3.779   1.551   4.498   7.379 

Coefficients:
               Estimate Std. Error t value Pr(>|t|)   
(Intercept)     -12.638      8.013  -1.577  0.13129   
Temp_Va_nCoast    5.549      1.862   2.980  0.00769 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 5.255 on 19 degrees of freedom
Multiple R-squared:  0.3186,	Adjusted R-squared:  0.2827 
F-statistic: 8.883 on 1 and 19 DF,  p-value: 0.007687
```

3.6 Validating the assumption that Temperature has influence on Number of Persons Employed in Accommodation and Restaurants (NPEAR) in non-coastal zone of Italy.

```
> summary(lm(NPEAR_Va_nCoast1~Temp_Va_nCoast))

Call:
lm(formula = NPEAR_Va_nCoast1 ~ Temp_Va_nCoast)

Residuals:
    Min      1Q  Median      3Q     Max 
-7.9981 -6.3625  0.1258  4.0820  9.5648 

Coefficients:
               Estimate Std. Error t value Pr(>|t|)  
(Intercept)      -6.072      8.864  -0.685   0.5016  
Temp_Va_nCoast    4.007      2.059   1.946   0.0666 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 5.813 on 19 degrees of freedom
Multiple R-squared:  0.1662,	Adjusted R-squared:  0.1223 
F-statistic: 3.787 on 1 and 19 DF,  p-value: 0.06661
```

3.7 Validating the assumption that Temperature has influence on Number of Bars and Tobacco Shops (NBT) in non-coastal zone of Italy.

```
> summary(lm(NBT_Va_nCoast1~Temp_Va_nCoast))

Call:
lm(formula = NBT_Va_nCoast1 ~ Temp_Va_nCoast)

Residuals:
    Min      1Q  Median      3Q     Max 
-8.6779 -4.8644 -0.0838  4.5634  9.1466 

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)      14.482      8.567   1.691    0.107
Temp_Va_nCoast   -1.097      1.990  -0.551    0.588

Residual standard error: 5.618 on 19 degrees of freedom
Multiple R-squared:  0.01574,	Adjusted R-squared:  -0.03607 
F-statistic: 0.3038 on 1 and 19 DF,  p-value: 0.5879
```

3.8 Validating the assumption that Temperature has influence on Wages of Employees in Bars and Tobacco Shops (WEBT) in non-coastal zone of Italy.

```
> summary(lm(WEBT_Va_nCoast1~Temp_Va_nCoast))

Call:
lm(formula = WEBT_Va_nCoast1 ~ Temp_Va_nCoast)

Residuals:
   Min     1Q Median     3Q    Max 
-6.665 -3.602 -0.018  2.448  7.377 

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)     -0.7598     6.8201  -0.111    0.912
Temp_Va_nCoast   2.1010     1.5845   1.326    0.201

Residual standard error: 4.473 on 19 degrees of freedom
Multiple R-squared:  0.0847,	Adjusted R-squared:  0.03653 
F-statistic: 1.758 on 1 and 19 DF,  p-value: 0.2006
```

3.9 Validating the assumption that Temperature has influence on Number of Persons Employed in Bars and Tobacco Shops (NPEBT) in non-coastal zone of Italy.

```
> summary(lm(NPEBT_Va_nCoast1~Temp_Va_nCoast))

Call:
lm(formula = NPEBT_Va_nCoast1 ~ Temp_Va_nCoast)

Residuals:
    Min      1Q  Median      3Q     Max 
-9.4773 -4.3328 -0.1168  3.2422  8.6686 

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)       4.934      8.456   0.584    0.566
Temp_Va_nCoast    1.122      1.965   0.571    0.575

Residual standard error: 5.545 on 19 degrees of freedom
Multiple R-squared:  0.01688,	Adjusted R-squared:  -0.03486 
F-statistic: 0.3262 on 1 and 19 DF,  p-value: 0.5746
```

3.10 Validating the assumption that Temperature has influence on Investment – Gross Fixed Capital Formation (GFCF) in non-coastal zone of Italy.

```
> summary(lm(GFCF_num~Temp_Val_num))

Call:
lm(formula = GFCF_num ~ Temp_Val_num)

Residuals:
    Min      1Q  Median      3Q     Max 
-9.1732 -5.5304  0.4212  5.5304  9.1420 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)     4.354      9.584   0.454    0.655
Temp_Val_num    1.560      2.227   0.701    0.492

Residual standard error: 6.285 on 19 degrees of freedom
Multiple R-squared:  0.02518,	Adjusted R-squared:  -0.02612 
F-statistic: 0.4909 on 1 and 19 DF,  p-value: 0.492

> cor(Temp_Val_num,GFCF_num)
[1] 0.1586945
```

4.0 Temperature and Time Regression Analysis (Panel Data Analysis) for Coastal Regions

```
> phtest(fixed_Temp,random_Temp) #Hausman test

        Hausman Test

data:  Year_Coast1 ~ Temp_Coast
chisq = 22.463, df = 1, p-value = 2.142e-06
alternative hypothesis: one model is inconsistent

> fixed_analysis_Temp <- plm(Year_Coast1 ~ Temp_Coast, data=Coastal_Data
+                            index=("Year"), model="within")
> summary(fixed_analysis_Temp)
Oneway (individual) effect Within Model

Call:
plm(formula = Year_Coast1 ~ Temp_Coast, data = Coastal_Data,
    model = "within", index = ("Year"))

Balanced Panel: n = 21, T = 6, N = 126

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-10.65575  -2.01679   0.12841   2.12882  10.65575

Coefficients:
           Estimate Std. Error t-value  Pr(>|t|)
Temp_Coast -3.74712    0.75253 -4.9794 2.544e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    1785
Residual Sum of Squares: 1441.4
R-Squared:      0.19251
Adj. R-Squared: 0.029458
F-statistic: 24.7941 on 1 and 104 DF, p-value: 2.5441e-06
```

5.0 Linear Regression Analysis for Italy at the National Level

5.1 Validating the assumption that Temperature has influence on Night spent at tourist accommodation (NSTA) at National Level

```
> summary(lm(NSTA_Italy~TEMP_Italy))

Call:
lm(formula = NSTA_Italy ~ TEMP_Italy)

Residuals:
    Min      1Q  Median      3Q     Max 
-4.7178 -1.8019  0.8007  2.3786  3.8007 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  -70.345     30.064  -2.340   0.0414 *
TEMP_Italy     5.395      2.110   2.557   0.0285 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.94 on 10 degrees of freedom
Multiple R-squared:  0.3953,	Adjusted R-squared:  0.3349 
F-statistic: 6.538 on 1 and 10 DF,  p-value: 0.02852
```

5.2 Validating the assumption that Temperature has influence on Total International Receipt (TIR) at the National Level

```
> summary(lm(TIR_Italy~TEMP_Italy))

Call:
lm(formula = TIR_Italy ~ TEMP_Italy)

Residuals:
    Min      1Q  Median      3Q     Max 
-4.6379 -2.5175  0.6272  2.0455  3.6272 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  -78.191     27.875  -2.805   0.0186 *
TEMP_Italy     5.945      1.956   3.039   0.0125 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.726 on 10 degrees of freedom
Multiple R-squared:  0.4802,	Adjusted R-squared:  0.4282 
F-statistic: 9.238 on 1 and 10 DF,  p-value: 0.01247
```

5.3 Validating the assumption that Temperature has influence on Total International Expenditure (TIE) at the National Level

```
> summary(lm(TIR_Italy~TEMP_Italy))

Call:
lm(formula = TIR_Italy ~ TEMP_Italy)

Residuals:
    Min      1Q  Median      3Q     Max 
-4.6379 -2.5175  0.6272  2.0455  3.6272 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  -78.191     27.875  -2.805   0.0186 *
TEMP_Italy     5.945      1.956   3.039   0.0125 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.726 on 10 degrees of freedom
Multiple R-squared:  0.4802,    Adjusted R-squared:  0.4282 
F-statistic: 9.238 on 1 and 10 DF,  p-value: 0.01247
```

5.4 Validating the assumption that Temperature has influence on Gross Fixed Capital Formation (GFCF) at National Level

```
> summary(lm(GFCF_Italy~TEMP_Italy))

Call:
lm(formula = GFCF_Italy ~ TEMP_Italy)

Residuals:
    Min      1Q  Median      3Q     Max 
-4.6805 -1.8250  0.7196  2.3327  3.7196 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  -74.012     29.088  -2.544   0.0291 *
TEMP_Italy     5.652      2.041   2.769   0.0198 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.845 on 10 degrees of freedom
Multiple R-squared:  0.434,     Adjusted R-squared:  0.3774 
F-statistic: 7.667 on 1 and 10 DF,  p-value: 0.01982
```

5.5 Validating the assumption that Temperature has influence on Number of Establishments (NE) at the National Level

```
> summary(lm(NE_Italy~TEMP_Italy))

Call:
lm(formula = NE_Italy ~ TEMP_Italy)

Residuals:
    Min      1Q  Median      3Q     Max 
-5.4737 -2.0137  0.8461  2.2934  3.8461 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  -68.292     30.578  -2.233   0.0496 *
TEMP_Italy     5.250      2.146   2.447   0.0344 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.991 on 10 degrees of freedom
Multiple R-squared:  0.3745,	Adjusted R-squared:  0.312 
F-statistic: 5.987 on 1 and 10 DF,  p-value: 0.03444
```

5.6 Validating the assumption that Temperature has influence on Number of Bed places (NB) at the National Level

```
> summary(lm(NB_Italy~TEMP_Italy))

Call:
lm(formula = NB_Italy ~ TEMP_Italy)

Residuals:
    Min      1Q  Median      3Q     Max 
-4.6700 -0.9924  0.0724  2.3114  3.6969 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  -75.038     28.801  -2.605   0.0262 *
TEMP_Italy     5.724      2.021   2.832   0.0178 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.817 on 10 degrees of freedom
Multiple R-squared:  0.4451,	Adjusted R-squared:  0.3896 
F-statistic: 8.022 on 1 and 10 DF,  p-value: 0.01778
```

5.7 Validating the assumption that Temperature has influence on Number of Accommodation and Restaurants (NAR) at the National Level

```
> summary(lm(NAR_Italy~TEMP_Italy))

Call:
lm(formula = NAR_Italy ~ TEMP_Italy)

Residuals:
    Min      1Q Median      3Q     Max 
-6.045 -2.614  1.037  2.677  4.396 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  -33.316     36.554  -0.911    0.384
TEMP_Italy     2.795      2.565   1.090    0.301

Residual standard error: 3.575 on 10 degrees of freedom
Multiple R-squared:  0.1061,	Adjusted R-squared:  0.01675 
F-statistic: 1.187 on 1 and 10 DF,  p-value: 0.3014
```

5.8 Validating the assumption that Temperature has influence on Wages of Employees in Accommodation and Restaurants (WEAR) at the National Level.

```
> summary(lm(WEAR_Italy~TEMP_Italy))

Call:
lm(formula = WEAR_Italy ~ TEMP_Italy)

Residuals:
    Min      1Q  Median      3Q     Max 
-4.6872 -1.6446  0.5606  2.3463  3.7342 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  -73.352     29.270  -2.506   0.0311 *
TEMP_Italy     5.606      2.054   2.729   0.0212 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.863 on 10 degrees of freedom
Multiple R-squared:  0.4269,	Adjusted R-squared:  0.3696 
F-statistic: 7.449 on 1 and 10 DF,  p-value: 0.02122

> 
```

5.9 Validating the assumption that Temperature has influence on Number of Persons Employed in Accommodation and Restaurants (NPEAR) at the National Level

```
> summary(lm(NPEAR_Italy~TEMP_Italy))

Call:
lm(formula = NPEAR_Italy ~ TEMP_Italy)

Residuals:
    Min      1Q  Median      3Q     Max 
-4.6469 -1.9852  0.6467  2.0009  3.6467 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  -77.311     28.140  -2.747   0.0206 *
TEMP_Italy     5.884      1.975   2.980   0.0138 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 2.752 on 10 degrees of freedom
Multiple R-squared:  0.4703,	Adjusted R-squared:  0.4173 
F-statistic: 8.878 on 1 and 10 DF,  p-value: 0.01382
```

5.10 Validating the assumption that Temperature has influence on Number of Bars and Tobacco Shops (NBT) at the National Level

```
> summary(lm(NBT_Italy~TEMP_Italy))

Call:
lm(formula = NBT_Italy ~ TEMP_Italy)

Residuals:
    Min      1Q  Median      3Q     Max 
-5.1585 -2.6509 -0.1432  2.4174  5.3702 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   37.883     37.367   1.014    0.335
TEMP_Italy    -2.203      2.622  -0.840    0.420

Residual standard error: 3.655 on 10 degrees of freedom
Multiple R-squared:  0.06594,	Adjusted R-squared:  -0.02747 
F-statistic: 0.7059 on 1 and 10 DF,  p-value: 0.4204

>
```

5.11 Validating the assumption that Temperature has influence on Wages of Employees in Bars and Tobacco Shops (WEBT) at the National Level

```
> summary(lm(WEBT_Italy~TEMP_Italy))

Call:
lm(formula = WEBT_Italy ~ TEMP_Italy)

Residuals:
    Min      1Q  Median      3Q     Max 
-5.7091 -3.1139  0.3931  2.3773  5.2574 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   30.331     37.921   0.800    0.442
TEMP_Italy    -1.673      2.661  -0.629    0.544

Residual standard error: 3.709 on 10 degrees of freedom
Multiple R-squared:  0.03802,   Adjusted R-squared:  -0.05818 
F-statistic: 0.3952 on 1 and 10 DF,  p-value: 0.5437
```

5.12 Validating the assumption that Temperature has influence on Number of Persons Employed in Bars and Tobacco Shops (NPEBT) at the National Level

```
> summary(lm(NPEBT_Italy~TEMP_Italy))

Call:
lm(formula = NPEBT_Italy ~ TEMP_Italy)

Residuals:
    Min      1Q  Median      3Q     Max 
-5.5041 -2.6553 -0.0659  3.0259  4.8912 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  18.2321    38.4849   0.474    0.646
TEMP_Italy   -0.8236     2.7006  -0.305    0.767

Residual standard error: 3.764 on 10 degrees of freedom
Multiple R-squared:  0.009215,  Adjusted R-squared:  -0.08986 
F-statistic: 0.09301 on 1 and 10 DF,  p-value: 0.7666
```