The University of Pardubice

Faculty of Economics and Administration

Circular Economy Indicators as a Supporting Tool for Regional Development

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Master Thesis
2023

University of Pardubice
Faculty of Economics and Administration
Academic year: 2022/2023

ASSIGNMENT OF DIPLOMA THESIS

(project, art work, art performance)

Name and surname:	**Osborn Agyenim Boateng**
Personal number:	**E21894**
Study programme:	**N0488A050002 Regional Development and Governance**
Work topic:	**Circular economy indicators as a supporting tool for Regional development**
Assigning department:	**Institute of Economic Sciences**

Theses guidelines

The aim of the thesis is to analyze the influence of circular economy indicators on regional development in selected European countries. The student first defines the concept of circular economy, then defines its main indicators and analyzes their impact on regional development. Part of the thesis will be to define the role of the public sector in stimulating the environmental behavior of selected regional stakeholders.

Contents:
- The concept of Regional Development.
- Circular Economy indicators as a tool for Regional Development.
- Analysis of Circular Economy indicators as a tool for Regional Development.
- Discussions and Conclusion.

Extent of work report:	**approx. 50 pages**
Extent of graphics content:	**–**
Form processing of diploma thesis:	**printed/electronic**
Language of elaboration:	**English**

Recommended resources:

Alden, J., & Boland, P. (2013). Regional development strategies: a European perspective. Routledge.ISBN: 9781315000220
Cumberland, J. H. (2018). Regional development: Experiences and prospects in the United States of America (Vol. 2). Walter de Gruyter GmbH & Co KG.ISBN :9781125877005
Del Río, P., Kiefer, C. P., Carrillo-Hermosilla, J., & Könnölä, T. (2021). Circular Economy. Springer International Publishing.ISBN:9783030747923
Sillanpää, M., & Ncibi, C. (2019). The circular economy: case studies about the transition from the linear economy. Academic Press.ISBN:9780128152676
Torre, A., & Wallet, F. (2016). Regional development in rural areas: Analytical tools and public policies. Springer.ISBN:9783319023717
Weenk, E., & Henzen, R. (2021). Mastering the Circular Economy: A Practical Approach to the Circular Business Model Transformation. Kogan Page Publishers.ISBN:1398602744

Supervisors of diploma thesis:	**doc. Ing. Viktor Prokop, Ph.D.** Institute of Economic Sciences
Date of assignment of diploma thesis:	**September 1, 2022**
Submission deadline of diploma thesis:	**April 30, 2023**

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In Pardubice September 1, 2022

DECLARATION OF AUTHOR

Author's Declaration I

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ACKNOWLEDGEMENT

I would want to thank everyone who helped me with my research and thesis from the bottom of my heart. I owe a tremendous debt of gratitude to my supervisor Doc. Ing Viktor Prokop, Ph.D. for his wisdom, insight, and constant encouragement during my thesis. The direction and quality of my thesis have been greatly influenced by their perceptive input, constructive criticism, and important counsel.

In addition, I would want to express my gratitude my lovely wife, Miss Juliet Afriyie and to my four kids. Also, I would like to express my gratitude to the members of the advisory board, whose thoughtful comments and ideas have significantly improved the quality of this study. Their knowledge and insight have helped improve the research process, data analysis, and overall presentation of this study.

In addition, I would like to give credit where credit is due and thank the researchers and academics whose studies served as the basis for this one. Thanks to their work, I now have a firm foundation on which to construct my research and theory. The completion of this research would not have been possible without the help of the resources and facilities made available to me by University of Pardubice. In order to analyse data and provide useful insights, having ready access to the appropriate literature, databases, and computational tools has proven crucial.

Finally, I would want to give my sincere thanks to everyone who has been there for me and been so encouraging, supportive, and patient during my time in school. Their confidence in me and unending support have been driving forces in my life. It would be impossible to name everyone who had a role in making this research a success, but please know how grateful I am to everyone who did.

Thank you all for your support and assistance.

ANNOTATION

The aim of the thesis is to analyse the influence of circular economy indicators on regional development in selected European countries. The study explains the concept of circular economy, then defines its main indicators and analyses their impact on regional development. The study adopted Czech Republic, Germany and Netherlands as case study countries to examine their circular economy indicators on regional development indicator Gross Domestic Product (GDP). The study found that circular economy indicators such as Waste Management, Secondary raw materials, Production and Consumption, and National Budget expenditure on environmental protection have significant positive impacts on regional development indicator Gross Domestic Product (GDP) in the three countries, Czech Republic, Germany and Netherlands.

KEY WORDS:

Region, Development, Innovation, Circular Economy, Indicators

ANOTACE

Cílem práce je analyzovat vliv indikátorů oběhového hospodářství na regionální rozvoj ve vybraných evropských zemích. Studie vysvětluje pojem oběhové hospodářství, následně definuje jeho hlavní ukazatele a analyzuje jejich vliv na regionální rozvoj. Studie přijala Českou republiku, Německo a Nizozemsko jako země případové studie, aby prozkoumala jejich ukazatele oběhového hospodářství na ukazateli regionálního rozvoje hrubého domácího produktu (HDP). Studie zjistila, že ukazatele oběhového hospodářství, jako je nakládání s odpady, druhotné suroviny, výroba a spotřeba a výdaje státního rozpočtu na ochranu životního prostředí, mají významný pozitivní dopad na ukazatel regionálního rozvoje hrubý domácí produkt (HDP) ve třech zemích, České republice, Německu a Nizozemsku.

KLÍČOVÁ SLOVA

Kraj, Rozvoj, Inovace, Cirkulární ekonomika, Ukazatele

CONTENTS

INTRODUCTION

The idea of a circular economy has been progressively acknowledged as a sustainable and resource-efficient method for fostering economic growth. In the pursuit of a more sustainable future, circular economy indicators have emerged as valuable tools for guiding regional development towards greater sustainability and resilience. The aim of the thesis is to analyse the influence of circular economy indicators on regional development in selected European countries. The study explains the concept of circular economy, then defines its main indicators and analyses their impact on regional development.

The study presents the concepts of regional development and indicators of regional development such as Gross Domestic Product (GDP). The study also explores the concepts of circular economy and the major role it plays in achieving sustainable regional development. The indicators of circular economy are also presented and explains how these indicators impact on the regional development.

The study adopted quantitative design to examine the relationship between independent variables and the dependent variables by employing multiple linear regression. Circular economy indicators such as Waste Management, Secondary raw materials, Production and Consumption, and National Budget Expenditure on Environmental Protection were the independent variables and the regional development indicators such as Gross Domestic Product (GDP) and Global Sustainability and resilience (GSR) were the dependent variables. The study found that circular economy indicators, Waste Management, Secondary raw materials, Production and Consumption, and National Budget expenditure on environmental protection has significant positive impacts on regional development indicators such as Gross Domestic Product (GDP) and Global Sustainability and resilience (GSR).

1 DEFINITION OF REGION AND REGIONAL DEVELOPMENT

This chapter will analyse the key variables of the study topic. Firstly, the definition of regions will be given and explained, then an analysis of an overview on regional development.

The study also explores previous research findings from studies that have been done. It ends with the theories that will guide the study.

1.1 Definition of Region

The region is an example of integrated organizational manifestation within a limited geographical environment, according to the concept of classical regional geography (Vanhove, 2018). The area stands for the end result of global territorial differentiation. The region, which corresponds with territorial units in traditional regional geography analysis is where spatial and social processes are connected (Florida, 2017; Bergman and Feser, 2020). Herbertson provided the first definition of the word "region" in a 1905 article. Herbertson claims that the natural environment embodies the oneness of configuration, climate, and vegetation.

The indicators that are used in defining region differs based on the question or problem that is under review (Acs et al., 2017). Region was derived from the Latin word “regio” which means territory, landscape, area, which is part of the surface of the Earth (Vestnik, 2017). A region is also said to be spatial system which is delimited and exhibits organizational unity by differentiating it from other regions (Klapka, Halás and Tonev, 2013; Halás, 2016). The term region is used to refer to a particular territorial division with a distinct human population for administrative, economic, or ecological purposes (Acs et al., 2017). It also refers to a clearly defined and organised portion of the Earth's surface with a variety of distinguishing qualities. This means that region involves both the physical characteristics and socio-economic characteristics (Halás, 2016).

The combination of these socio-economic characteristics gives the socio-economic region (Vestnik, 2017). Other scholars also believe that region does not involve socioeconomic factors but rather behavioral factors (Akcigit and Ates, 2021).

1.2 Concept of Regional Development

When regions undergo growth and adjustment processes, they experience inequalities in economic, social, and environmental results (Filenta and Kydros, 2022). The spread of prosperity over a region is at the heart of the concept of regional development. The fields of regional science, economic geography, economic growth theory, and regional economics all owe a great deal to its contributions (Nijkamp and Abreu, 2009).

This shows the continuous effort by regional development to ensure the correction of the various unevenness and imbalances that are found within the boundaries of a state (Bærenholdt, 2009). This means the general problem that regional development seeks to address are the inequalities that exists in the various states and regions (Higgins, 2017). These inequalities come in the form of unequal share of wealth and income. This when unresolved, have a very high level of effect on the economy and other areas of the state which includes (Higgins, 2017):

- outmigration of investment capital and the productive or young segment of the population,
- low level of welfare,
- dependence on a means of production that is subsistence

Undeniably, this will worsen the situation in the rural areas thereby causing them to seek for refuge in the urban areas hence, causing a high level of deficiencies in housing, social services and employment, and a potential for political unrest. This makes the need for regional development more paramount and crucial. The unequal development of states requires the use of knowledge and innovation to distribute resources in order to prevent the high risk that comes with regional inequality (Capello and Nijkamp, 2019). Effective input and conversations are essential to the success of understanding and creative activities, but this can only be achieved in a supportive setting (Ascani et al., 2012).

Thus, local economic agents, knowledge, and innovative activities interact differently depending on the local social, political, and institutional conditions (Rodríguez-Pose, 1999). In this respect it is very important to conceive regional development as one that stems from innovativeness, competitiveness, and productive capacity which are all locally induced (Capello, 2009). This means that there is no regional entrepreneurial policy that can be applied to another region (Todtling and Trippl, 2005) without adjustment else it will lead to a loss of human resources, time, and capital (Jha, 2007). However, a successfully implemented regional development policy of one region can be applied to another region given that the regions share similar characteristics – these are (Jha, 2007):

- cultural,
- institutional,
- organizational, ● geographic.

1.2.1 Current concept of regional development

Economic growth, according to the Endogenous Growth Theory, originates from inside an economy rather than being imposed from without (Roufagalas and Orlov, 2020). The hypothesis is in opposition to the neoclassical growth model, which attributes the growth to endogenous factors like improved technology (Akcigit and Ates, 2021). Endogenous growth theory contests this neoclassical paradigm by providing mechanisms through ways economic factors may slow down technological progress, and hence, economic development over the long term (Henrekson et al., 2021).

Several concepts have been developed on the understanding of regional development. The most notable one is with respect to the use of endogenous capabilities (Jha, 2007). This is a result of the believe by some scholars that the region can only achieve its long-term development goal if it uses endogenous capabilities and other specific properties (Bergman and Feser, 2020). In their analysis of the relationship between endogenous growth theory and regional performance, Pan and Ngo (2016) found that globalization efforts boost regional growth in regions that have set up special economic zones using liberal governmental oversight.

Their empirical review prior to the study however disagreed that in situations where regional per capita income tended to converge across areas and where increased It is true that there was a favourable correlation between FDI inflow, capital expenditure, and openness to trade, and GDP growth. They disagree with Vanhove (2018) findings that the structure of economic growth (zero growth vs. continual growth), the origins of technical change (exogenous vs. endogenous), and the character of changes in technology (exogenous vs. endogenous) are the fact that the market is in equilibrium (a perfect market/the occurrence of market failures) are the main differences between Neoclassical (exogenous) and Endogenous growth theories.

As part of 1.3, I would now introduce the theoretical concepts

1.3 Selected theories of regional development

1.3.1 Endogenous growth theory

Economic activities that generate new technical knowledge are the source of long-term growth, according to the endogenous growth theory. Long-term economic development at a pace set by factors inside the economic system, in this case, the possibilities and incentives to create technical knowledge, is called endogenous growth (Aghion et al., 1998). Over time, technical advancement determines the rate of total factor productivity (TFP), which in turn determines the pace of economic growth as measured by the growth rate of production per person. The pace of technological advancement is treated as though it were governed by a scientific process in the neoclassical growth theory of Solow (1956) and Swan (1956).

Therefore, according to neoclassical theory, economists can treat the exogenous longrun growth rate as if it were endogenous. In contrast to this neoclassical paradigm, endogenous growth theory proposes mechanisms via which economic considerations might impact the rate of technological advancement and, by extension, the long-run rate of economic growth. It begins with the realization that innovations new products, processes, and markets are the driving force behind technological advancement, and that many of these inventions are the direct outcome of economic activity.

Because businesses gain knowledge about how to maximize efficiency via practice, a more active economy can speed up the rate at which new production processes are developed. Economic policies on trade, competition, education, taxes, and intellectual property can affect the pace of innovation by changing the private costs and benefits of conducting R&D. This is because many innovations are the product of R&D expenditures performed by profit-seeking enterprises.

1.3.1.1 AK Model

The AK hypothesis was the first iteration of endogenous growth theory, and it failed to differentiate between capital accumulation and technical advance. It effectively grouped the physical and human capital whose accumulation is analysed by neoclassical theory with the intellectual capital that is accumulated when innovations occur. Frankel (1962), a pioneer in the field of AK theory, proposed the idea that the marginal product of capital in the aggregate production function need not be constant. This is because the marginal product of capital tends to decline, but this trend can be counteracted by technical advancements made possible by the increasing capital that businesses collect. Output Y is proportional to the stock of capital K if and only if the marginal product of capital is constant.

$$Y = AK$$

where A is a positive constant. Hence the term ‘AK theory’

A nation's long-term growth rate is determined by its saving rate, as per the AK hypothesis. For instance, if savings are always at a constant percentage (s) of production and depreciation is always at a constant percentage (d), then the rate of total net investment is

$$\frac{dK}{dt} = sY - dK$$

which along with (1) implies that the growth rate is given by: g =

$$\frac{1}{Y}\frac{dY}{dt} = \frac{1}{K}\frac{dK}{dt} = sA - d.$$

Therefore, a sustained boost in growth can be achieved by increasing the saving rate s. To counter Frankel's assumption of a constant saving rate, Romer (1986) conducted a similar study using a broader production structure, whereby saving is attributed to the maximising of intertemporal utilities. Like Uzawa (1965), Lucas (1988) provided an approach that equated human capital with technological knowledge but focused on human capital rather than physical capital.

1.3.2 Institutional and Noninstitutional theories

1.3.2.1 Growth Pole Theory

In 1949, Francois Peroux was the first to use the concept of a growing pole. In particular, he looked at the economic factors that distinguish growth poles in his study. However, there is a lack of consensus among subject matter experts about the growth poles, especially when considering the writers' respective areas of expertise. As a result, numerous economists, geographers, and area development specialists have different views on the growth poles. Conventional wisdom is that a growth pole is an entire sector of the economy or at least a specialized subset of it, such as a group of related companies. At its tip, a growth pole might be either a single firm or a cluster of industries.

However, Perroux located centres of expansion using his concept of "abstract economic space." He classifies this nebulous economic space as one of three types: an economic plan, a field or force of effects, or a homogeneous aggregate. In Perroux's view, the poles of the national economy are a collection of both active (motor industries, poles of geographically agglomerated industries and activities) and passive (affected industries, areas dependent on geographically agglomerated industries and activities) industrial systems.

The "economic spaces" rather than the "geographic areas" are the primary emphasis of Perroux's approach (Perroux, 1950). It is the poles or foci of these "economic spaces" that serve as the sources of centrifugal forces and the sinks for centripetal pressures. This provides the foundation for the emergence of new theories of uneven growth with more nuanced geographical implications. Negative growth spill overs from more developed regions to less developed regions are not counterbalanced by positive growth spill overs, as argued by Myrdal (1957) (also known as "backwash effects").

1.3.2.2 Circular Cumulative Causation Theory

Myrdal is credited with developing the idea of circular cumulative causation, which proposes that changes in a negative direction result in a cumulative shortening process while changes in a positive direction result in a cumulative lengthening process. The existence of "growing spots" or "growth poles," according to Hirschman (1958), demonstrates that regional and worldwide growth disparity is necessary for growth to occur. Hirschman proposes a two-region model of growth, arguing that the "advanced North" will have a beneficial (trickle-down) influence on the "less developed South" if the two economies are complementary, but will have a negative (polarising) effect if the two economies are competing.

Boudeville (1966) extends Perroux's concept of the economic space to the physical world by defining a regional growth pole as a cluster of flourishing businesses in a metropolitan area. A growth pole is a significant urban center that is propelled by an economic engine that, while it may not employ the most people, has the greatest direct or indirect influence on the region's prosperity and activity. A propulsive industry has a direct and indirect dominant influence on all other activities and resulting in an oligopolistic industrial concentration, whereas polarisation is the industrialization and diversification process put in motion by industry or industrial complex.

According to Friedmann's (1967) core-periphery model for polarised development, innovation and progress occur from a limited number of hubs located at strategic nodes in the area of communication. Typically, development moves to more remote areas where the probability of a link is minimal. Peripheral regions are all the other areas inside a given spatial system, whereas core regions are the ones that are always evolving and leading the pack. The dialectics of polarization, as outlined by McKee (1987), illustrates how centers of stagnation can emerge from pre-existing development poles. Promoting expansions in service activities is one way to mitigate the negative effects of the shifts. When looking at growth-pole plans as a part of regional economic planning, Parr (1999a, 1999b) distinguishes between four stages. Starting in the early 1960s, policymakers frequently presented growth pole choices for a specific issue region setting.

This method is extended to deal with additional regional or interregional challenges and government involvement after a Keynesian intervention in the late 1960s. In the early 1970s, policymakers abandoned the aforementioned strategy due to changes in the global and national economies and a revaluation of the level of state intervention. By the mid-1970s and later, the growth-pole approach seemed to have fallen out of favour in regional economic planning. The author maintains that in many cases, decision-makers pushed for the implementation of the growth-pole strategy before the issue had been adequately diagnosed. One could say that the issue was more regional.

By studying the impact of major cities' economic growth on smaller cities and counties, Ke and Feser (2010) draw the conclusion that growth poles in major cities can generate both positive and negative regional growth spillovers. Christofakis and Papadaskalopoulos (2011) investigate Greek polar concentrations and recommend a sectoral policy to draw propulsion. Some developing nations will serve as growth poles in the emerging world, say Popkova et al. (2016), who compare the GDP growth rates of various countries across time.

The global economy in the wake of the crisis. Pysar (2017) employs the "growth poles" hypothesis to identify the most productive regions of Ukraine, arguing that investing in those regions' industries will have a multiplier effect on the country's economy. Since the Romanian economy is so unequally distributed, a new general socioeconomic model of development is required, one that gives priority to the country's economically and socially depressed regions and creates an index based on county-level economic and social data for a given year (Strat and Stefan, 2017).

1.4 Determinants of regional development

Regional development can be influenced by several factors/determinants. Regional or development is the consequence of multiple factors, conditions, or agents working together, but in distinct ways. Several classical authors who supported the theories of growth poles (Perroux, 1950) and cumulative causation (Myrdall, 1957) as well as others who stressed the significance of transaction costs have examined it. The interaction of numerous economic, social, cultural, institutional, and environmental elements leads to regional growth; as a result, each region's intensity and form of development are influenced by the depth and level of articulation of these interactions (Gennaioli et al., 2013).

Regional development is determined by innovation, competitiveness, technology, human capital, tourism, infrastructures and equipments (Giannakis and Bruggeman, 2017; Bronzini and Piselli, 2008). However, this study will concentrate on three of these determinants which are; innovation, technology, and human capital. This is because these determinants are considered as the key variables which cannot function independently. Obviously, a human with innovation but does not have technology cannot implement it.

The table 1 below shows an empirical review of the various determinants of regional development

Table 1: Selected determinants of regional development

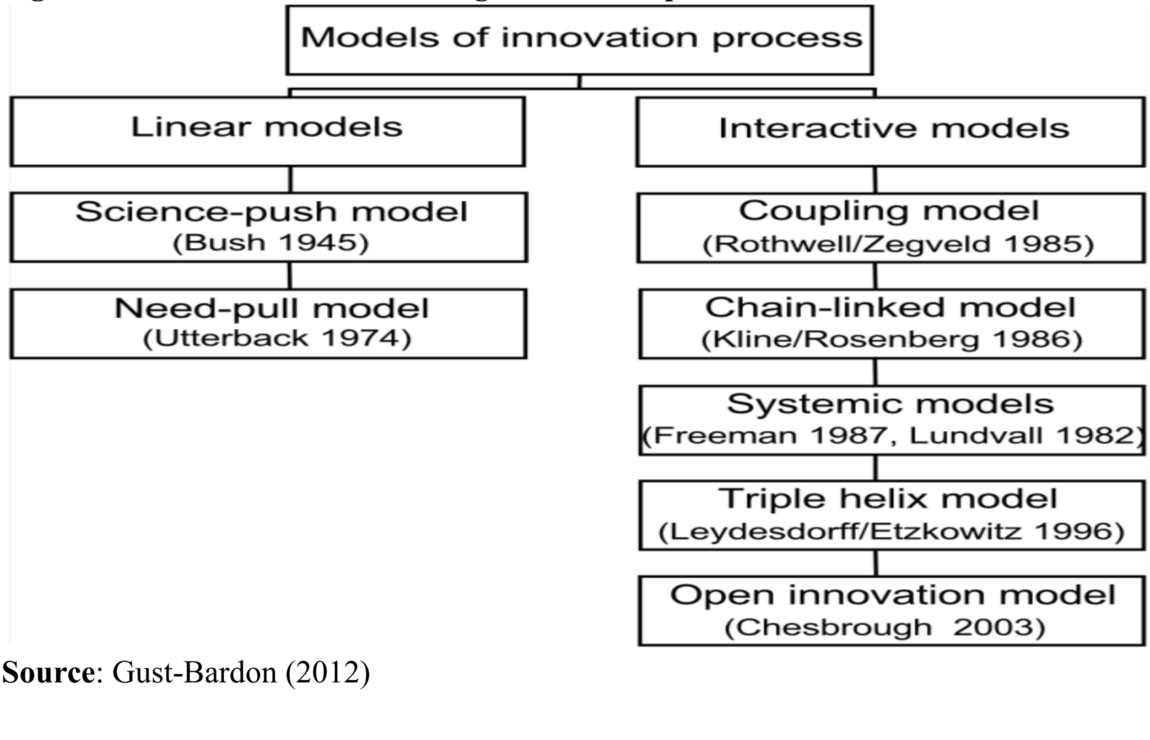
Determinant	Topic	Finding

Innovation	Regional innovation system (in) efficiency and its determinants: an empirical evidence from Italian regions (Barra and Zotti, 2015). a. Regional Development in the Context of an Innovation Process (Gust-Bardon, 2012). A case of Sophia Antipolis	a. R&D in the universities and private sector is important for regional innovation. b. Inputs (highly qualified human resources, networking cooperation, openness, policy, infrastructure, creative destruction, etc) interaction lead to regional development mechanism which leads to endogenous development process in the region.
Technology	Technology and Regional Development: A Survey (Malecki, 1983) . An exploratory study on the determinants of performance in regional industry technology development programs (Park and Shin, 2017).	a. 1. Traditional approaches to technology include those found in models of regional growth, in analyses of innovation diffusion, and in economic analysis of technological change. 2. Recent research on regional development has involved technology from two perspectives—that of regional economic structure and that of innovation in the strategies and management of large corporations. 3. Underdevelopment of Third World countries has been attributed in part to technological dependence. b. Technological change, technological difficulty, competition between domestic and foreign competitors and the technological gap had positive effects on performance, excluding sales contributions
Human Capital	a. Human Capital as the Main Determinant of Regional Economic Growth (Prasetyo, 2020). Human Capital and Regional Development (Genaiaoli et.al, 2011).	a. Human capital can give the main and dominant contribution to encourage the regional micro and macroeconomic growths. b. Human capital is important in accounting for regional differences in development, but also suggests from model estimation and calibration that entrepreneurial inputs and human capital externalities are essential for understanding the data.
Highly Qualified Human Resources	a. The Human Resources As An Important Factor Of Regional Development (Jašková & Havierniková, 2020) b. Human capital and regionaldevelopment (Faggian et al., 2019)	a. High Qualified human resources present the aspect of socioeconomic development, prosperity competitiveness of each region due to the ·ibute to increasing of employment, development inha orking places and improving the life standard of ıts. b. The study found that skill labour is essential ıe development regional countries.

Networking Cooperation	Towards an evolutionary perspective on regional resilience (Boschma, 2015)	The study foind that networking cooperation creates resilient regions that are capable of overcoming a trade-off between adaptation and adaptability.
Openness	Trade openness and regional development in a developing country (Pernia & Quising, 2005)	The study found that trade openness appea beneficial to regional economic growth a growth, poverty reduction. However, it cannot be expected to bring about more balanced development.
Policy	Regional innovation patterns and the EU regional policy reform: towards smart innovation policies (Camagni & Capello, 2017)	The study found that regional countries adop policy documents strategy promote smart sustainable and inclusive growth
Infrastructure	Infrastructure investment and its impact to regional development (Sebayang & Sebayang, 2020)	The study found that infrastructure pro tendency to improve regional economies with variations in the short term in terms of quantit (economic growth, quality aspects (Human Development Index), and variations in competitive advantage. Infrastructure investm has a different impact associated with r regional inequality

Source: Researcher's Own Construct

Figure 1: Innovation Process to Regional Development



Source: Gust-Bardon (2012)

Gust- Bardon's model of the creative process serves as the basis for this investigation (2012). While the linear model places more emphasis on tacit knowledge, the interactive model places greater emphasis on the interdependencies of its constituent parts. The most useful asset of the interactive model is thought to be its emphasis on different kinds of information and the connections between them, and the most crucial step in the model is thought to be interactive learning itself (Lundvall, 1992; Johannessen, 2009). The interplay between organizational, technical, and environmental contexts is emphasized in the interactive innovation paradigm.

Coupling Model

This model considers the innovation process to be a web of interdepartmental and extramural connections (i.e. linking a company with a wider scientific and technological community as well as with a broader market). According to Rothwell (1994), an organization's innovation process is the sum of its members acquired technological expertise and the demands of its target market (Gust-Bardon, 2012).

Chain Link Model

The Kline model, devised by Kline and Rosenberg (1986), recognizes the potential role of science in each step of the innovation process and the reversibility of technological progress. Direct and indirect links between marketing and research are both recognized as being important by the approach. The first step is to determine what people want in the market. The second phase entails coming up with an analytical layout. Finally, in Stage 3, efforts are made to meet the needs that have been identified. The third stage integrates testing into a comprehensive design. After a few tweaks in the fourth step, the product is finally made. The last phase are promoting and delivering the new product or service to consumers.

The various actions are shown as boxes that, when clicked on, expand to disclose further details. The "knowledge" box is an "integrative element" (Bonjour & Micali, 2010) called a pool, whereas some of the others represent quite narrowly focused endeavors (research, design, produce, etc.). This repository is the hub around which an innovation system revolves. Relationships between the boxes might be either iterative ("loops") or linear ("flow channels of information and cooperation") (Kline & Rosenberg, 1986). It's possible to categorize some of them as continuous and others as conditional or event-based.

In other words, they rely on the occurrence of specific events (market signals that trigger expectations and projects in innovators) or the assumption of certain facts (if innovators need more knowledge, they obtain it from the pool of knowledge). There are direct connections to and from research that can help solve invention and design issues quickly (Kline & Rosenberg, 1986). The process of innovation in CLM is both bottom-up and top-down, with a strong emphasis on both. Below is a comprehensive breakdown of each phase;

First Path

The primary chain of invention refers to this path. Starting with an analytical design, the process culminates in the development and dissemination of an invention.

Second Path

It's the series of actions (f) between connected points in the inventive procedure. Important feedback (F) links the last step back to the beginning of the process. According to this source, a corporation may better identify new markets (new customers' desires) by drawing on the knowledge it has gained throughout the process' final step (based on data from consumers) (UNIDO, 2004).

Third Path

These are the ties that bind new ideas to scientific progress (D). This link is determined by the state of our collective knowledge; if an issue that develops during the five stages might be fixed by using what we already know (at node K), then the study stops there (the link 3 to R becomes redundant).

Fourth Path

This is a prototypical example of how academic inquiry can lead to ground-breaking innovation. While Kline and Rosenberg acknowledge that this phenomenon is rare, they argue that when it does occur, the ensuing innovation fundamentally alters entire industries. Semiconductors, lasers, atomic bombs, and genetic engineering are just a few examples of such breakthroughs.

Fifth Path

This line of reasoning shows how novel products influence scientific inquiry (I), as well as how keeping an eye on external changes might benefit scientific inquiry (S). According to Kline and Rosenberg, the development of medicine would have been slowed down if Louis Pasteur's work hadn't been feasible without the use of a microscope.

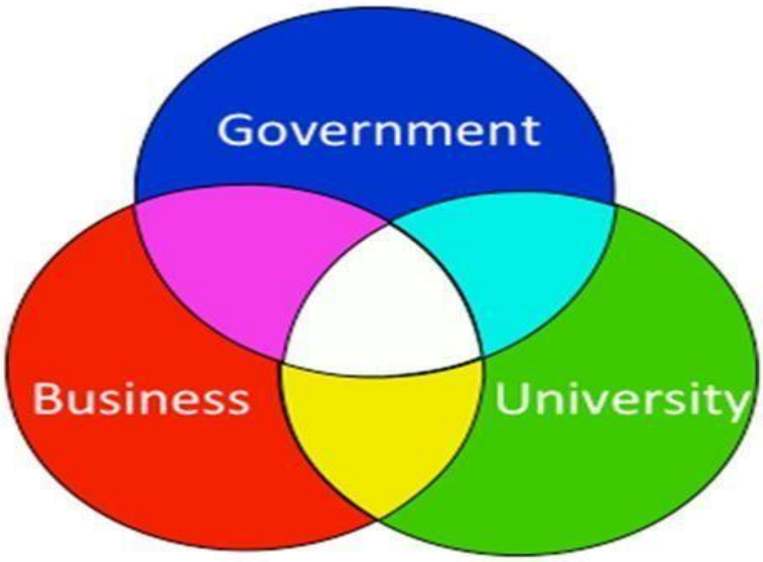
1.5 Triple Helix Model

Constant dialogue between universities, businesses, and governments is crucial to the triple helix model of innovation, which in turn promotes economic and social progress (Leydesdorff, 2012). The concept places a premium on encouraging inventiveness for progress. It lays forth the university's obligation to work with private enterprises and public agencies. It illustrates how we as a society have developed certain social structures for the creation, dissemination, and application of knowledge (Galvao et al., 2019). The idea of "creative destruction," first articulated by economist Joseph Schumpeter in 1942, explains the process by which new ideas replace older ones. Triple Helix discusses this phenomenon. Each of these three institutions the university, the private sector, and the public sector is a source of innovation. Because of the nature of the invention, creative destruction is inevitable. Creative thinking often has unintended negative effects on the economy (Etzkowitz et al., 1995).

It was in the 1990s when Henry Etzkowitz and Loet Leydesdorf created Triple Helix. Silicon Valley is the greatest illustration of the Triple Helix model. The IT cluster in California, USA, was given land, adaptable funding, prolonged tax vacations, and conducive regulations by the government. This area was a hotspot for both large and small information technology companies. Companies like Dell, HP, Oracle, Intel, Microsoft, etc. have shown the world that success is possible (Galvao et al., 2019).

Academic institutions, in this instance, made up of ICT experts who are provided with optimal conditions for conducting R&D and new product creation, are required since the demands of industry, driven by the newly formed market, necessitate their presence. Taxes on product sales bring in money for the government, profit for businesses, and new insights for academic institutions when they are housed in an optimal setting for scientific inquiry (Etzkowitz et al., 1995).

Figure 7: Triple Helix Strategic Interactions



Source: Etzkowitz and Leydesdorf (1995)

1.5.1 Three Components of the Model

The Triple Helix Model of innovation proposed by Etzkowitz and Leydesdorff, the creative process revolves around the mutual influences of the three components listed below, each of which plays an important "initial role" in the process (Leydesdorff 2012). This includes both fundamental researches conducted by universities and commercial commodities produced by businesses and regulated by governments. Hybrid institutions emerge as a result of increased interaction within this framework, with one component eventually adopting certain traits of the other institution. University, business, and government all engage with one another (Leydesdorff 2012).

i. University-Industry Interactions

According to Etzkowitz and Leydesdorff, universities' primary function is to teach and conduct fundamental studies. Therefore, those two factors serve as the starting point for exchanges between academia and industry. According to the traditional "linear model" of innovation, academic institutions are responsible for doing the fundamental research upon which commercial items are subsequently built. Managers in both industries, as well as academics from both institutions, engage with one another. Etzkowitz claims that the movement of people from academia to industry represents a crucial exchange of information. This may include a definitive shift in focus from one area to the other, or it may describe a lifetime of work split evenly between the two fields. He uses Carl Djerassi, a former research director for a pharmaceutical business and current professor at Stanford University, as an example (Leydesdorff, 2012)

However, some academics have warned that faculty members' consulting work can have negative consequences, such as a bias against teaching and a potential conflict of interest when it comes to using university resources for the benefit of industry (Boyer et al. 1984). Informal communication, conferences, and industrial interest in university publications are additional channels through which knowledge is transferred from university to industry. The MIT-General Electric course is one example of a co-op programme that aims to integrate an industry perspective into the curriculum through interaction with the business world (Sampat, 2006).

ii. University-Government Interactions

It is the government's overall connection with and policy toward higher education that determines the depth of contact between the government and institutions. The scope of these interactions is defined by a spectrum in the model developed by Etzkowitz and Leydesdorff. When universities and their research are predominantly funded by the government, as is the case in much of continental western Europe, the government may exert a great deal of control over both (Etzkowitz, 2008). On the other hand, in the United States, colleges get some public financing but are otherwise freer from direct government oversight. Nonetheless, both extremes of this spectrum are held up as models, rather than as the actual endpoints of the spectrum (Etzkowitz, 2011). Wartime conditions, for instance, and the need to support strategically important fields of study like physics might motivate the government to forge deeper relations with the academic community.

During World War II and the Cold War, the United States Department of Defense provided significant funding for physics research (Leslie, 1993). The Morrill Land-Grant Acts of 1862 provided funding for the development of land-grant institutions as another example of governmental participation in higher education. Seventy-six universities were founded as a result of the land-grant program, and three of them are Cornell University, the University of Florida, and Purdue University (Leslie, 1993).

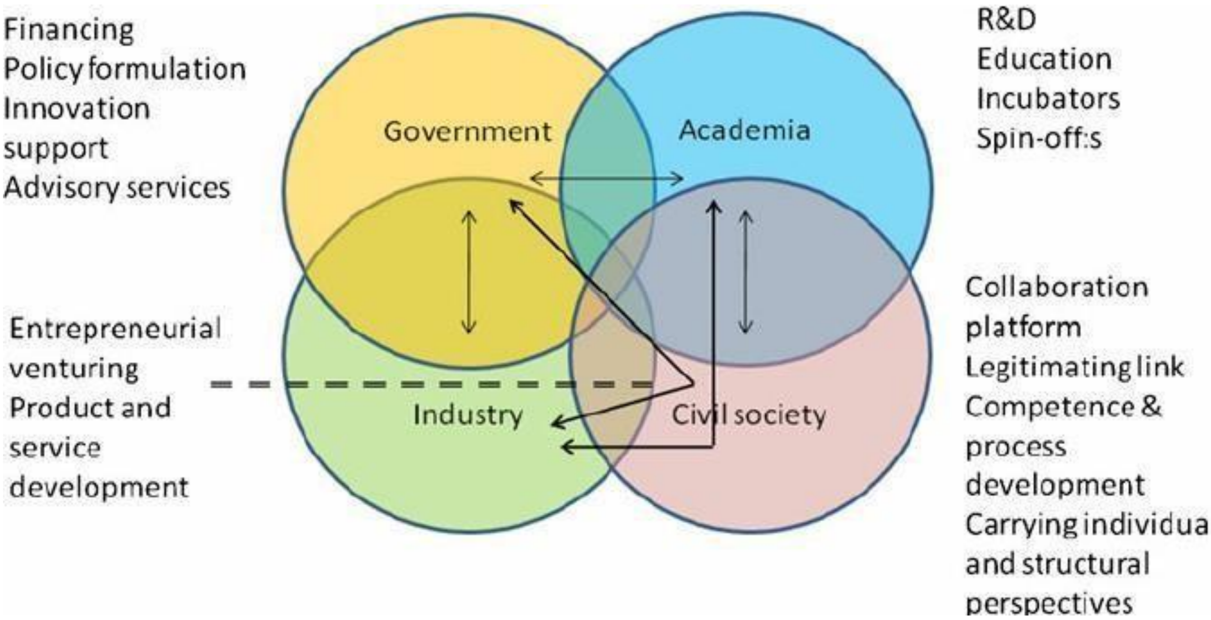
iii. Government-Industry Interactions

A nation's approach to the market determines the nature of its interaction with industry. The government's responsibility in a liberal economy is restricted to avoiding market failures. Conversely, in countries where the government has a larger role in the economy, the government's function is the regulation of industry. Both of these represent opposite extremes of a spectrum, with plenty of space for change depending on context and area of study. Bhaven Sampat notes that the government implemented a law in the 1960s to stop the commercialization of academic research financed by the National Institutes of Health through patents or licence agreements (Sampat, 2006). Establishing and enforcing intellectual property legislation is a crucial part of the government's relationship with the business sector.

1.5.2 Quadruple Helix Model

The quadruple helix concept expands on the triple helix by include the public, represented by civil society and the media, as a fourth pillar in the framework of interactions between the academy, industry, and government (Cavallini et al., 2016; Galvao et al., 2019). Elias G. Carayannis and David F.J. Campbell proposed it initially in 2009.

Figure 3: The Quadruple Helix Model



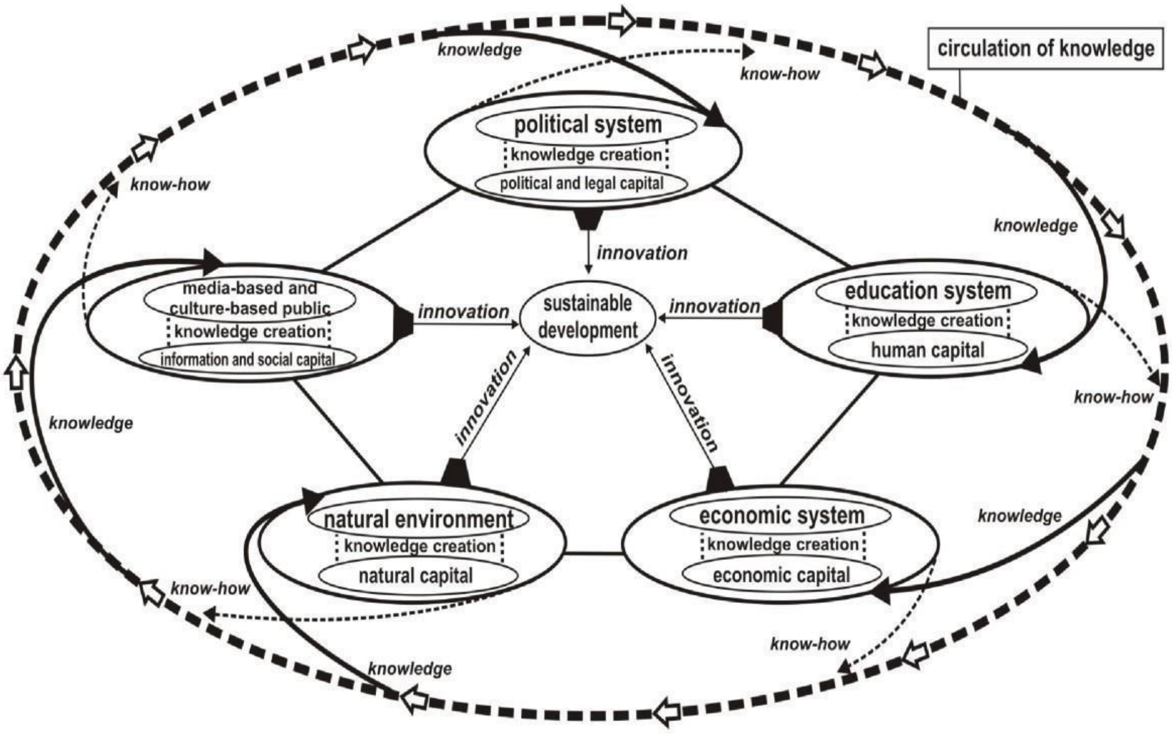
Source: Carayannis and Campbell (2009)

Under the Triple Helix Model, the framework argues, developing technologies do not necessarily fit the demands and requirements of society, limiting their potential influence. As a result, the framework places equal importance on universities' societal responsibilities as on their roles as educational institutions and research institutions (Cavallini et al., 2016). The European Union plans to pursue the quadruple helix method in order to build a competitive knowledge-based society. Since then, the European Union's Open Innovation 2.0 (OI2) policy for a digital single market that supports open innovation and the EU-MACS (EUropean MArket for Climate Services) project a follow-up to the European Research and Innovation Roadmap for Climate Services have all adopted the quadruple helix framework (Hubavem, 2013).

1.5.3 Quintuple Helix Model

Together with David F.J. Campbell, Elias G. Carayannis developed the Quintuple Helix Model in 2010. It borrows from the triple and quadruple helix models and superimposes the natural world as a fifth helix.

Figure 4: The Quintuple Helix Model



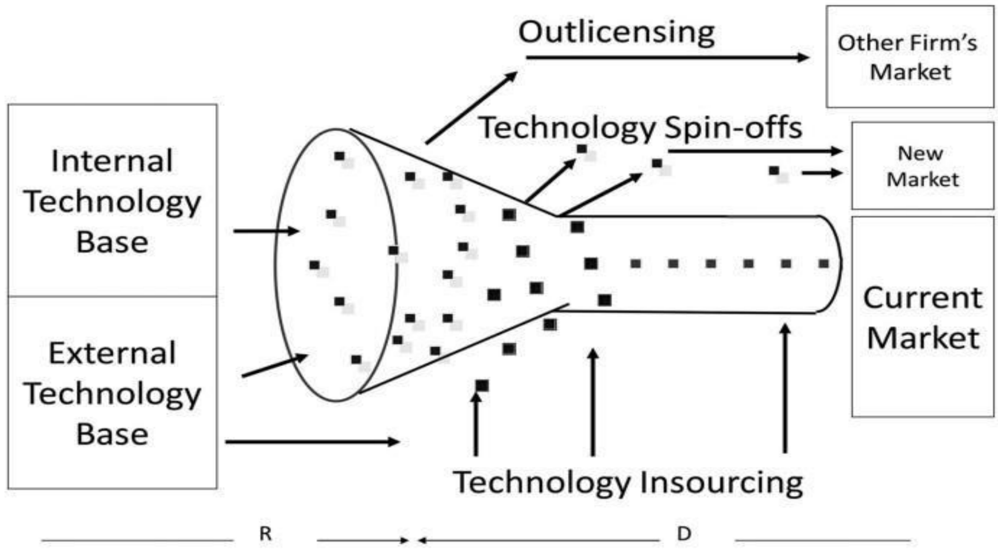
Source: Carayannis and Campbell (2010)

To define socio-ecological opportunities for the knowledge society and knowledge economy, such as innovation to address sustainable development, including climate change, the quintuple helix looks to the natural environments of society and the economy as drivers for knowledge production and innovation (Carayannis et al., 2012). The quintuple helix may be defined in terms of the knowledge models it encompasses, the five subsystems (helices) it integrates, and the processes involved in the dissemination of that information (Höglund et al., 2017). Some scholars consider the quadruple and quintuple helices to be extra helices, while others view them as distinct sorts of helix that overarch the earlier helices (Hubavem, 2012; Höglund et al., 2017).

1.5.5 Open Innovation Model

Adopting an open innovation strategy, companies may confidently commercialise innovations conceived both internally and outside, without fear of retaliation for doing so. That model predicts greater economic innovation than would occur if rivals were forbidden from adopting any concept, including those that a company was unable to embrace, because companies are willing to share their ideas when they are unable to completely realise all of them.

Figure 5: Open Innovation Model



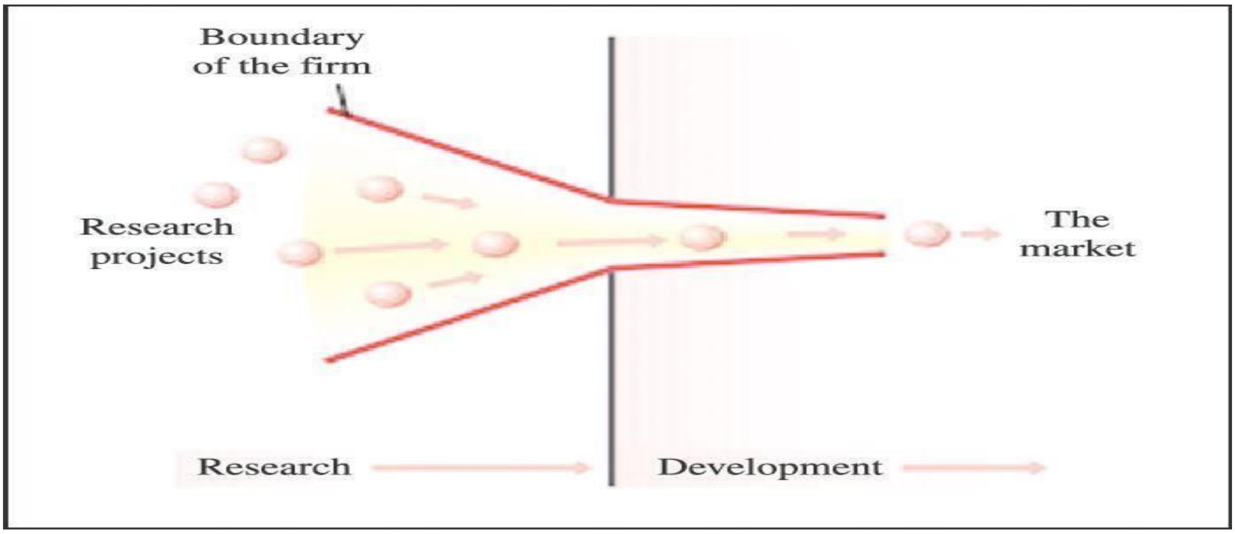
Source: Chesbrough (2022)

The scientific and technological foundation of the company serves as the starting point for research projects under the closed model of innovation. As they advance through the development process, some initiatives are abandoned while others are chosen to receive additional attention. Due to the fact that projects can only enter and exit the traditional innovation process through the company's internal base, respectively, and only through the market, it is closed. In contrast, in the open innovation paradigm, initiatives may enter or exit at different times and in different ways (Chesbrough, 2022). The outside-in component of the concept is applied here, where initiatives can be started from either internal or external technology sources, and new technology can enter the process at different phases. Projects can also advance their ways to advertise, such as throughout licensing or a spin-off venture company. In addition to using the company's internal marketing and sales channels.

1.5.5 Closed Innovation Model

The idea behind a Closed Innovation Model is that businesses create their own ideas.

Figure 6: Closed Innovation Model



Source: Chesbrough (2003)

The entire innovation process from brainstorming to production to promotion—occurs within the same organization. Place of innovation = within the company. Consequently, there is no way for it to open out to the outside. Only within the confines of a well-defined organisation can innovations be conceived and created. The pioneering firm keeps all rights to its innovations, including the know-how, technology, procedures, and intellectual property (Höglund et al., 2017). Its operation is similar to that of a perpetual motion machine (Chesbrough, 2003). Businesses put a lot of money into R&D in-house to make it a hub of expertise. These research and development divisions create ground breaking technologies that inspire new goods and approaches. Therefore, the innovation process is defined by a closed system, with rigid business borders and in-house R&D initiatives.

2 CIRCULAR ECONOMY

This chapter delves into the concept of Circular Economy, which has gained significant attention in recent years as a sustainable economic model (Winans, Kendall, & Deng, 2017).

The traditional linear economic model of "take, make, use, and dispose" has resulted in the depletion of resources and environmental degradation, among other issues. In contrast, a Circular Economy aims to keep resources in use for as long as possible by designing products that can be reused, repaired, or recycled. This chapter explores the principles and benefits of a Circular Economy, as well as the challenges and opportunities that it presents. It also examines real-world examples of Circular Economy initiatives and policies that are being implemented across different sectors and regions. This chapter provides an insightful overview of the Circular Economy and its potential to transform the way we consume and produce goods and services, for a more sustainable future.

2.1 The Concept of Circular Economy (CE)

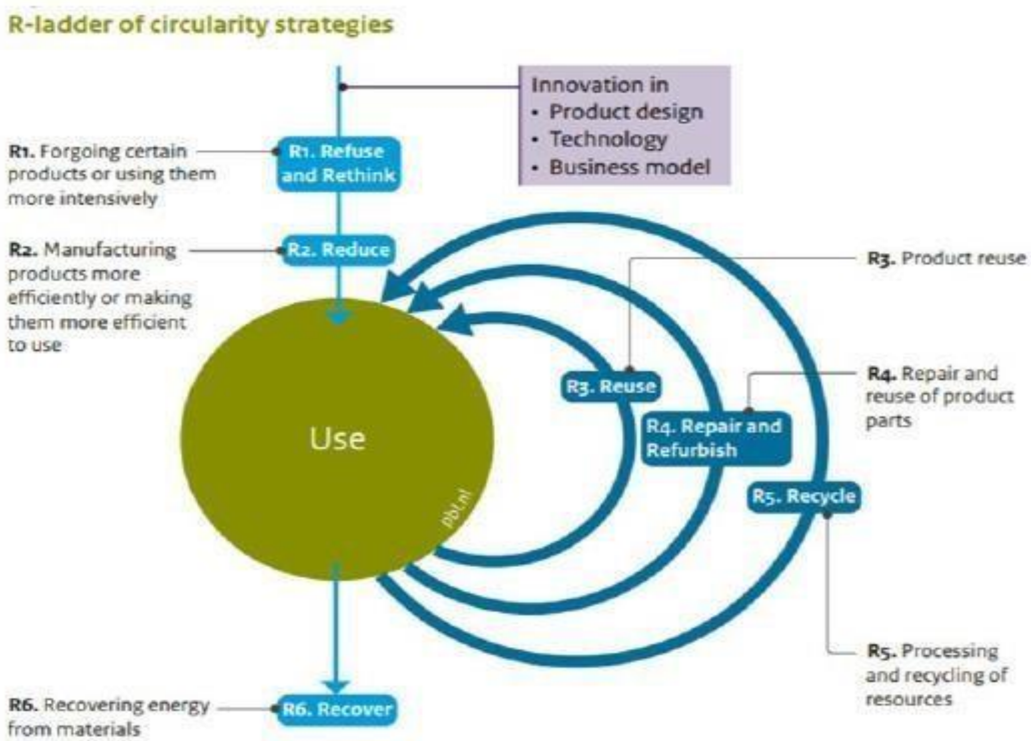
The existing linear economic structure is seen as the root cause of environmental problems such as water, air, and soil pollution, resource depletion, biodiversity loss, etc. The circular economy (CE) is seen as a potential solution to these problems (Geissdoerfer, Savage, Bocken, & Hultink, 2017). The phrase "circular economy" has been around since the 1970s, however, its precise origin is unknown. Several prominent academics wrote at this time on the correlation between the linear nature of the economic system and the concept of Earth as a closed system (Geissdoerfer et al., 2017). In addition, the limits to growth study published by the Club of Rome in 1972, as well as other well-known sustainability theories, have undoubtedly served as inspirations (Winans, Kendall, & Deng, 2017).

Since the 1970s, the idea of CE has been getting more and more attention. One reason for this is that, at least in the eyes of academics and professionals, the idea is more approachable and proactive than the idea of Sustainable Development (Kirchherr, Reike, & Hekkert, 2017). Nonetheless, the CE has been criticized for being disorganized and incoherent (Korhonen, Honkasalo, & Seppälä, 2018). This is because the idea of CE has developed in a variety of ways across various social, economic, and political structures. For instance, air pollution is just one of many major environmental concerns depicted in the Chinese vision of the CE. The rapid pace of development and the resulting environmental problems have prompted this reaction. In contrast, the European Union's (EU) view of CE is more focused, with an emphasis on waste and resource management and possibilities for enterprises (Avdiushchenko & Zajc, 2019).
Therefore, the geographical scope of this research will be limited mostly to Europe and the CE idea.

The CE notion is, nevertheless, still rather wide, especially within the European context. The CE is broken down into seven categories by Avdiushchenko & Zajc (2019): Economic growth, Zero waste, Energy efficiency and renewable energy use, New technology, Low carbon, Intelligence, Efficient use of space.

Materials, biodiversity, human society and culture, health and well-being, energy, social value, and water are all highlighted in research for the monitoring of the circular economy in the Metropole Region Amsterdam in the Netherlands (Metabolic 2018). Consequently, the scientific literature and policymakers apply different definitions of the CE since different parts of the economy are covered in the CE concept. The following European Commission definition will serve as the basis for this research. When items approach the end of their useful lives, resources are preserved inside the economy so that they may be reused to produce new value (European Union, 2015). This definition was selected because it places less emphasis on nonmaterial components of the circular economy, such as energy, biodiversity, etc., and so provides a clear scope while also distinguishing it from the broader idea of sustainable development. The European Commission provided the definition, and the Netherlands, as a member state of the European Union, is bound by it.

Figure 7: R-Ladder of Circularity Strategies



Source: Rood and Kishna (2019)

Strategies that aid in the elimination of main abiotic components are displayed on the Rladder. The R-strategies follow a hierarchical structure that is based on numerous different Rladders found in the research literature. As a general rule of thumb, less material will be required as R-strategy values increase. Avoiding or drastically altering the manufacturing of a

product is at the heart of R1, the most extreme R-strategy. R2 entails less material use by increasing the efficiency of production processes. Principles R1 and R2 limit or eliminate the use of primary resources. The R3, R4, and R5 concepts are used to extend the lifetime of materials inside the economic system. Products can be reused (R3), repaired and remanufactured (R4), and recycled (R5) to be utilized in the creation of brand-new items. Last but not least, the R6 concept involves creating energy by burning waste products that can't be recycled (Rood & Kishna, 2019). Three primary classes of R-strategies are distinguishable. Improved product usage and production
(R0-R2), longer product and component life (R3-R4), and practical material applications (R56) (Potting et al., 2018).

2.2 Implementation Levels of the Circular Economy

In Figure 8, the use of element's scope is represented at the product level, but it may be applied to other levels as well. Plan Bureau voor de Leefomgeving (PBL) a Dutch research institute that provides independent advice on the quality of the physical living environment in the Netherlands classifies the transition to a circular economy through four levels of aggregation: the national level, priority topics, regions, and types of products and services (Potting et al., 2018). The transition agendas developed by the Dutch government span several fields, and the top priorities reflect this. When thinking about the CE, Ghiselinni, Cialani and Ulgiati (2016) distinguish between three stages of application at the micro, meso, and macro levels (Figure 8). Individual goods or businesses make up the "micro" level. Factory complexes are seen at the meso level.

Everything from individual localities to (inter)national economies is included under the umbrella term "macro." Even though areas are identified as a macro implementation level by Ghiselinni et al. (2016), the distinction between macro and meso appears blurry. Eco-industrial parks are one type of regional or local application of the CE cited by Kalmykova, Sadagopan, and Rosado (2018). As part of an eco-industrial park, businesses pool their waste streams and use common facilities. Many such parks already exist in China; however, they are only considered to be operating at a meso level of implementation rather than at the macro level.

Since the regional level described in this study inside the Netherlands is not like the ecoindustrial parks commonly seen in China, this study focuses solely on the macro-level application of the circular economy within regions. Policy and its execution vary in scope and precision across the national, regional, and local levels; however, the macro level has been portrayed as overly wide in literature (Vanhamaki et al., 2019).

As a result, just because the regional and local levels are delegated to the macro level of implementation does not imply that the same indicators employed at the macro level will also be applicable at the regional and local levels.

Figure 8: Circular Economy: System Level Approach Retrieved

Source: Vanhamaki et al. **(**2019)

2.3 Transition to a Circular Economy in Regional Governments

Several levels of government should support the transition to a CE. The United Nations (UN) recognizes the unsustainable characteristics of the existing economic system, for instance, in its 2030 Sustainable Agenda. To reduce waste and pollution, businesses in the circular economy try to keep resources in circulation for as long as feasible. The United Nations'

Sustainable Development Goals (SDGs) 12 (sustainable production and consumption), 7 (affordable and clean energy), and 8 (decent job and economic development) see it as a potential solution or contribution to accomplishing these goals (Schroeder, Anggraeni & Weber, 2019).

2.3.1 European Union shift toward a circular economy

The European Union is dedicated to the global shift toward a circular economy. The Paris Climate Accord and the G7-Alliance for Resource Efficiency are only two examples of international commitments to improve resource efficiency (Vanhamaki et al., 2019). In addition, several policy papers have been drafted, such as the European Green Deal and action plans for the circular economy, such as "Towards a Circular economy" and "Closing the Loop" (Avdiushchenko & Zajc, 2019). The commitment of the European Union is shared by the Netherlands, and the country has made several steps toward a more circular economy. The Dutch government was recommended by the Council for the Environment and Infrastructure (RLi), which released the study CE, from the wish to reality (2015) in 2014.

They gave three interconnected arguments for why the Netherlands needs to adopt a circular economy. To begin, there is a persistent strain on Earth's ecosystem from the everincreasing demand for its resources. Already, this increasing demand is a cause for concern, and it will only worsen in the decades ahead if nothing is done. The Dutch reliance on foreign material supplies is intimately tied to this, second factor. Third, the Dutch will become more reliant on foreign nations to provide raw resources if they do not transition to a circular economy. As a result of this anticipated increase in demand, the Netherlands and its residents may be exposed to geopolitical shifts in their material consumption and to volatility in the cost of resources, which threatens supply security (RLi) in 2015 (Vanhamaki et al., 2019).

In addition, the climate goals may be helped by shifting to a circular economy. The Dutch government signed the Paris accord in 2013 to limit global warming to less than two degrees Celsius. Transitioning to a circular economy can help cut down on greenhouse gas emissions caused by the mining and production processes for new raw materials. However, climate goals and the circular economy aren't always compatible, especially when it comes to the use of biomass for power generation.

2.3.2 Netherlands Government Shifts towards Circular Economy

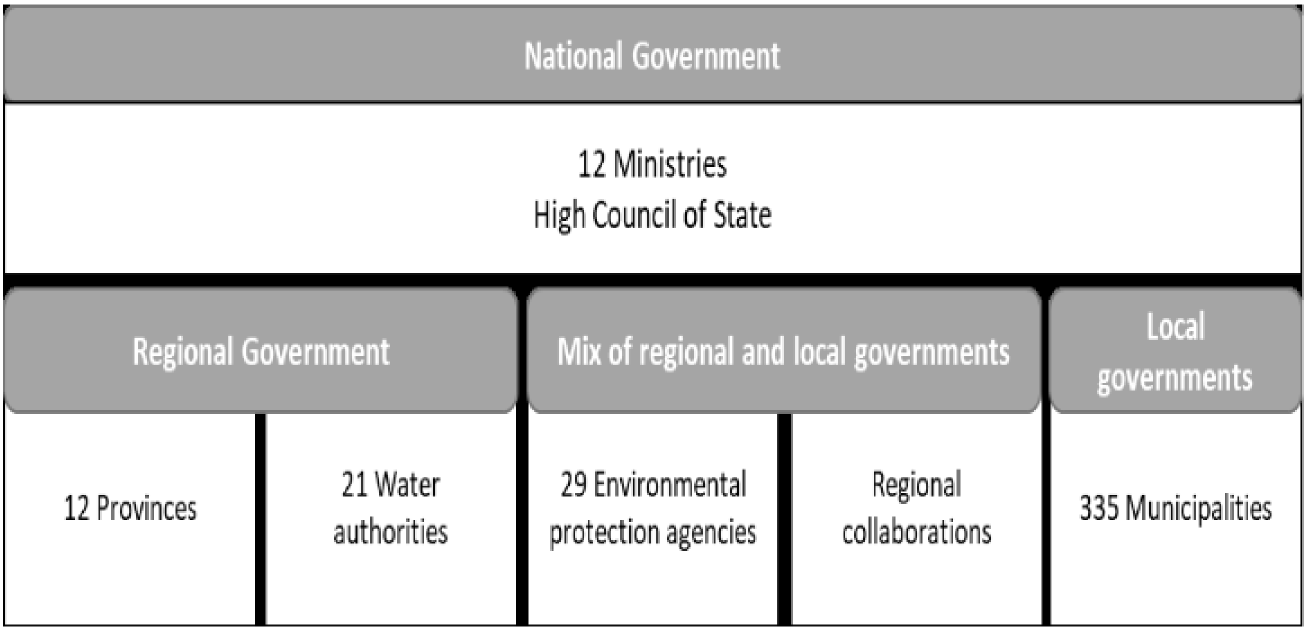
The Netherlands issued its "Nederland Circular in 2050" report in 2016. The goal of this strategic plan is to have a fully circular economy by the year 2050. In addition, a secondary goal of halving the use of virgin materials by the year 2030 has been established. The signing of the Raw Materials Agreement (Grondstoffenakoord) in 2017 marked a step in the right direction toward these objectives (Rood & Kishna, 2019). The Dutch government and 180 other partners, both government and private, have entered into this covenant to facilitate the transition to a circular economy. In 2018, signatories to the Raw Materials Agreement, in collaboration with the Dutch government, produced transition agendas for five sets of sectors crucial to the transition: building, biomass and food, plastics, manufacturing, and consumption.

They outline the ideal trajectory for many industries, as well as the accompanying steps and body of knowledge that must be taken on a micro, meso, macro, and global scale. Specific measures relating to transition agendas for 2019–2023 were announced in 2019 as part of the Circular economy Implementation Program (Van Buren, Demmers, Van der Heijden & Witlox, 2016). The foundations of the Dutch plan for a circular economy are the formulation of the Raw Materials Agreement, transition objectives, and the implementation program. The Dutch Government has tasked Plan Bureau Voor de leefomgeving (PBL), a Dutch agency for strategic policy analysis addressing nature and the (living) environment, with keeping track of the many initiatives aiming towards a circular economy. PBL's monitoring and guiding CE initiative includes revealing the current state of the circular economy in the Netherlands and how far the country is from achieving its goals (Rood & Kishna, 2019).

An all-encompassing shift in consumer habits, corporate culture, and policy is necessary to establish a circular economy (Van Buren et al., 2016). Rli's 2015 proposals may be primarily concerned with the federal government's part in the CE transition, but they also note the importance of paying attention to developing a systematic strategy for regional authorities. The transition to a CE should be tied to the growth of territorial economies, as pointed out by the Association of Cities and Regions for Sustainable Resource Management (ACR+). The ACR+ prioritizes local/regional/national/international determinations of territory before looking at more global/national/international ones (Association of Cities and Regions for Sustainable Resource Management, 2014). In recent years, some regional governments have adopted circular economy initiatives (Salvatori, Holstein, & Böhme, 2019). However, one of the least examined aspects is the regional perspective of shifting to a circular economy (Walendowski, Roman & Miedzinski, 2014).

It is important to establish what is meant by regional governments before delving into regional-level research on the transition to a circular economy. It is common parlance to distinguish between local and regional governments. In this context, local governments refer to governmental entities on the city or municipality level, whereas regional governments encompass those on the state or provincial level (Romano, 2018). The government of the Netherlands is split between central and two regional levels. The federal government, next the state or provincial government, which may include water authority, and ultimately the municipal government. In addition, regional entities and environmental protection agencies work together across jurisdictional boundaries (Figure 9).

Figure 9: Overview of governmental bodies on a national, regional and local level



Source: Rijksoverheid (2018)

In Figure 9, the five main regional and local governments in the region are presented. The provinces are intermediate authorities between the federal government and the municipalities. They are in charge of things at this level of administration. Local water agencies are in charge of things like water treatment and flood prevention on a regional scale. Joint efforts between nations are also common in environmental protection agencies. They are responsible for environmental monitoring and enforcement and are typically contracted by local and regional governments.

The regional body is a collaboration between municipal and regional administrations. Neighborhoods like Foodvalley and the Municipal Research Agenda (MRA) are good examples in the Netherlands (Metropole Region Amsterdam). Last but not least, municipalities are forms of local government that, terminologically speaking, are often interchangeable with cities, the term used more frequently in the international writing. In most cases, local administrations are only the implementers of legislative frameworks developed at higher levels, such as the provincial level (Gerritsen, 2011).

However, to keep things simple, this thesis will refer to all five governments as regional governments rather than local governments.

2.4 Circular Economy Strategies on the Regional Level

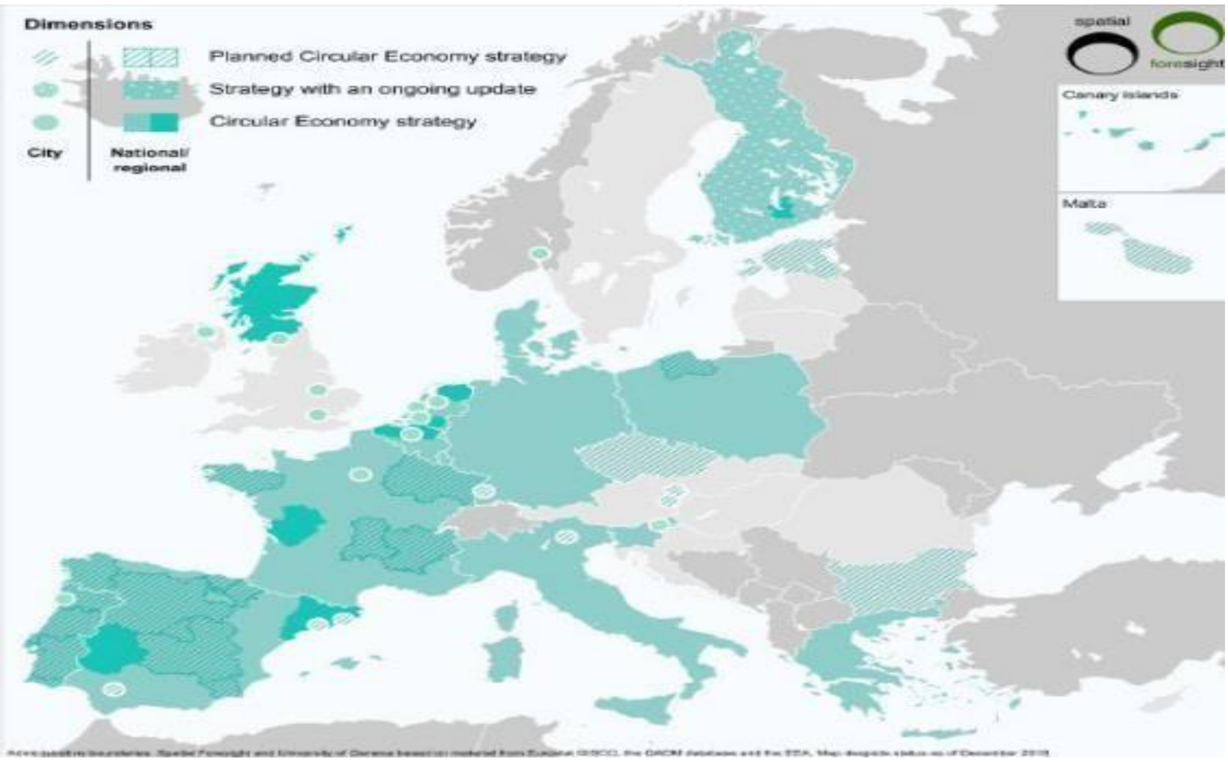
Regional governments are crucial to advancing the circular economy in European countries and beyond, even though it is unclear how the national goals are to be transferred to the regional level. In 2018, the OECD surveyed local governments and businesses about their efforts to implement a circular economy. The OECD argues that regions are essential because they serve as testing chambers for new ideas (Romano, 2018). According to the results of the poll, developing innovative business models, rethinking production and consumption, and bettering environmental quality are among the most important goals of areas making the switch to a circular economy. Furthermore, this poll indicates that cultural barriers, legislative frameworks, and financial resources are the primary challenges faced by regional administrations (Romano, 2018).

According to Kirchherr et al. (2018), who indicate that cultural barriers are widespread, cultural differences are the most prevalent problem. The absence of government participation in the market is the root source of these cultural barriers. Despite the challenges, some local governments are moving forward with developing and executing a CE plan. The move to a circular economy will have varied consequences depending on location (Walendowski, Roman, & Miedzinski, 2014). Therefore, to create a robust circular strategy, regional governments must gather insights into the unique characteristics of the region and the parties within this region (Avdiushchenko & Zajc, 2019). These are:

i. London's Circular Economy Route Map ii. Catalonia's
Green and Circular Economy Promotion Strategy iii.
Amsterdam's Circular Economy Action Plan
iv. are all examples of circular strategies in Europe

Circular Economy strategies and roadmaps are plans and initiatives designed to speed up the adoption of a circular economy. They provide a comprehensive strategy including goals, outcomes, and important next actions. Production, use, and disposal are all included, as well as other stages of the value chain (Salvatori, Holstein, & Böhme, 2019). Multiple European CE policies, both current and prospective, were analyzed by Salvatori et al. (2019). (Figure 9). Regional governments are crucial to advancing the circular economy in the Netherlands and beyond, even though it is unclear how the national goals are to be transferred to the regional level. In 2018, the OECD surveyed local governments and businesses about their efforts to implement a circular economy.

Figure 10: Existing and planned CE strategies on a national/regional level in Europe (2019)



Source: Salvatori, Holstein, and Böhme (2019)

Figure 10 displays the 33 CE techniques used by European countries. Some CE initiatives were identified at the regional level, however, national initiatives dominated. Promoting a Green and Circular Economy in Catalonia is only one of several regional CE policies in Spain. Several regional plans exist throughout France as well (e.g. The circular economy in Poitou- Charentes). In addition, several international hubs, including Paris, London, and Amsterdam, have developed their CE strategies.

2.4.1 Bio-based circular economy plans

Bio-based circular economy plans in Finland, Spain, Slovakia, Greece, Romania, and France were evaluated qualitatively by Vanhamaki et al. (2019). They concluded that proper waste disposal is crucial to the success of CE plans. In addition, Salvatori et al. (2019) classified national and regional initiatives into three distinct categories. One must first employ comprehensive plans that aim to influence public opinion in favour of the circular economy. Catalonia and the City of Paris both use CE methods as examples. Second, laser-targeted tactics. Participation is restricted to those with a vested interest in the aforementioned industries.

Other industries and interested parties are receiving little consideration. Included here is the Amsterdam circular, which serves as the city's and region's long-term plan and vision statement. Third, comprehensive plans with established priorities. (Steppingstones to a Circular economy 2019-2028 Brabant) and Northern Netherlands (Roadmap to a Circular North Netherlands). They call for extensive material loops and collaborative partnerships. Both Vanhamaki et al. (2019) and Salvatori et al. (2019) federal state, and local governments all developed CE plans. Other regional administrations, such as water agencies, were not found to have any CE strategies. One possible explanation is that not all European nations have specialized regional administrations like water authorities or environmental protection agencies.

Salvatori et al. (2019) looked into 33 CE plans, five of which were implemented in Dutch areas, of these, 21 were at the regional/local level. This demonstrates that the Dutch regional government is more engaged in developing a CE strategy than its European counterparts.

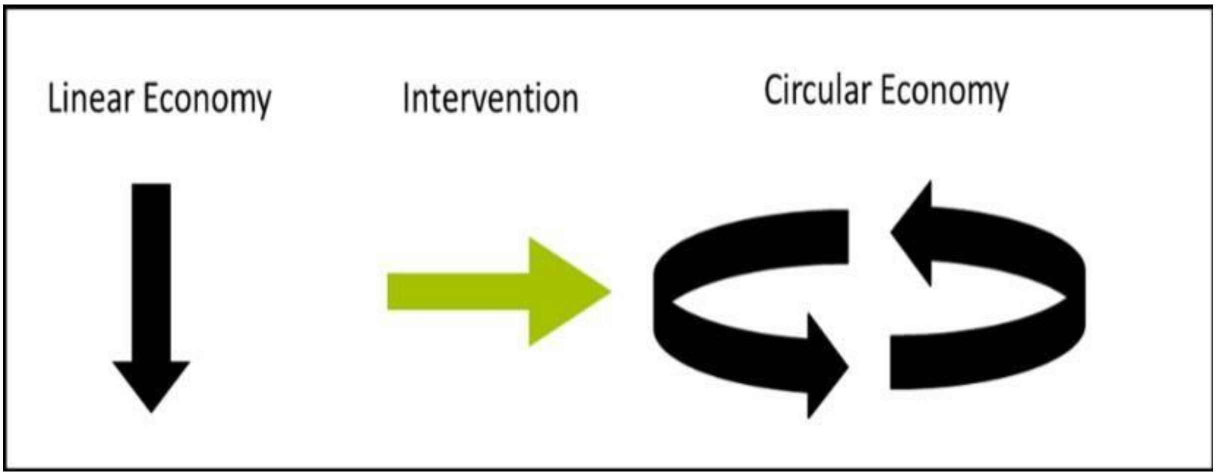
2.5 Regional Governments Policy Instruments

2.5.1 Steps of Policy Making

Regional governments use policy to stimulate, guide, and steer to achieve regional goals, whether those goals are connected to the circular economy or not. The policy cycle refers to the entire procedure that occurs between the formulation of an idea and its actual execution. The policy-cycle model illustrates the steps required to create, execute, and assess a policy. On the one hand, the cycle approach is no longer central to the study of policy because it is seen as an oversimplification that fails to account for the complexity of policymaking and provides insufficient information. On the other hand, it is viewed as a useful tool that emphasizes the malleability of policymaking and makes the process more manageable (Cairney, 2016).

There are a variety of policy cycles, but typically four to six stages may be distinguished, including agenda creation, formulation and adaptation, implementation, and assessment. CE strategies encompass agenda setting, formulation, and adaptation by detailing the goals that governments want to attain within a given time frame and the policy tools they employ to do so. What follow-up CE action may be expected from this plan now that these tools are being put into use? This allows for an assessment of the policies at last. The goal of the policies used in the transition to a circular economy is to intervene in the present system and make it more circular (Figure 11). In this context, the success of a policy depends on the capacity of the policy instrument to intervene and generate additional regional circularity.

Figure 11: Linear Economy to a circular economy



Source: Herrewijnen (2020)

2.5.2 Classification of Policy Instruments

In this way, CE plans have attainable goals and implementable tools. A policy instrument is "a technique used to assist transform a broad policy purpose into concrete action," as stated by Cairney (2019). Policy instruments are "tools of governance" according to Mees et al. (2014). They are tools (such as regulations and economic incentives) used to accomplish a goal that could not have been accomplished without government intervention (Winans, Kendall, & Deng, 2017). Various types can be identified when policy instruments are taken into account. The circular economy is simply one reason why policy tools are put into place. They're used in other contexts, too. This encompasses a wide range of topics within sustainability, from the implementation of policy tools to promote climate adaptation to the shift to renewable energy. Policy instruments and policy tools are commonly used interchangeably in the literature, as stated by Cairney (2019).

However, he distinguishes between the two by saying that "instruments" refer to a set of measures while "tools" refer to many main kinds of public policy instruments. In this analysis, we shall use the term "types of policy instrument" to refer to the same categories of instruments. Table 2.1 is a list of the seventeen policy tools provided by Cairney (2019).

Table 2: Classification of Policy Instruments Within Public Policy

Types of Policy Instruments	**Explanation**

1.Public expenditure	This includes deciding how to tax, how much money to raise, on which policy areas (crime, health, education) to spend and the balance between current (e.g. the wages of doctors) and capital (building a new hospital) spending.
2.Economic penalties	Penalties such as taxation on the sale of certain products, or charges to use services.
3.Economic incentives	Incentives such as subsidies to farmers or tax expenditure on certain spending (giving to charity, buying services such as health insurance).
4. Linking government-controlled benefits to behaviour	Seeking work to qualify for unemployment benefits) or a means test.
5. Control behaviour	The use of formal regulations or legislation to control behaviour.
6.Voluntary regulations	Regulations such as agreements between governments and other actors such as unions and business.
7.Linking the provision of public services to behaviour	Restricting the ability of smokers to foster children
8.Legal penalties	Penalties such as when the courts approve restrictions on, or economic sanctions against, organizations.
9.Public education	Public education and advertising to highlight the risks to certain behaviours.
10. Change behaviour	Providing services and resources to help change behaviour.
11. Tackle illegal behaviour	Providing resources to tackle illegal behaviour.
12. Funding organizations	Funding organizations to influence public, media and government attitudes
13. Support for scientific research	Funding scientific research or advisory committee works
14. Organizational change	Organizational change, such as the establishment of a new unit within a government department or a reform of local government structures
15.Providing services	Providing services directly or via nongovernmental organizations.
16. Setting up quasi-ma	Providing a single service or setting up quasi-ma

17. state service for free	Providing a state service for free charging or expect

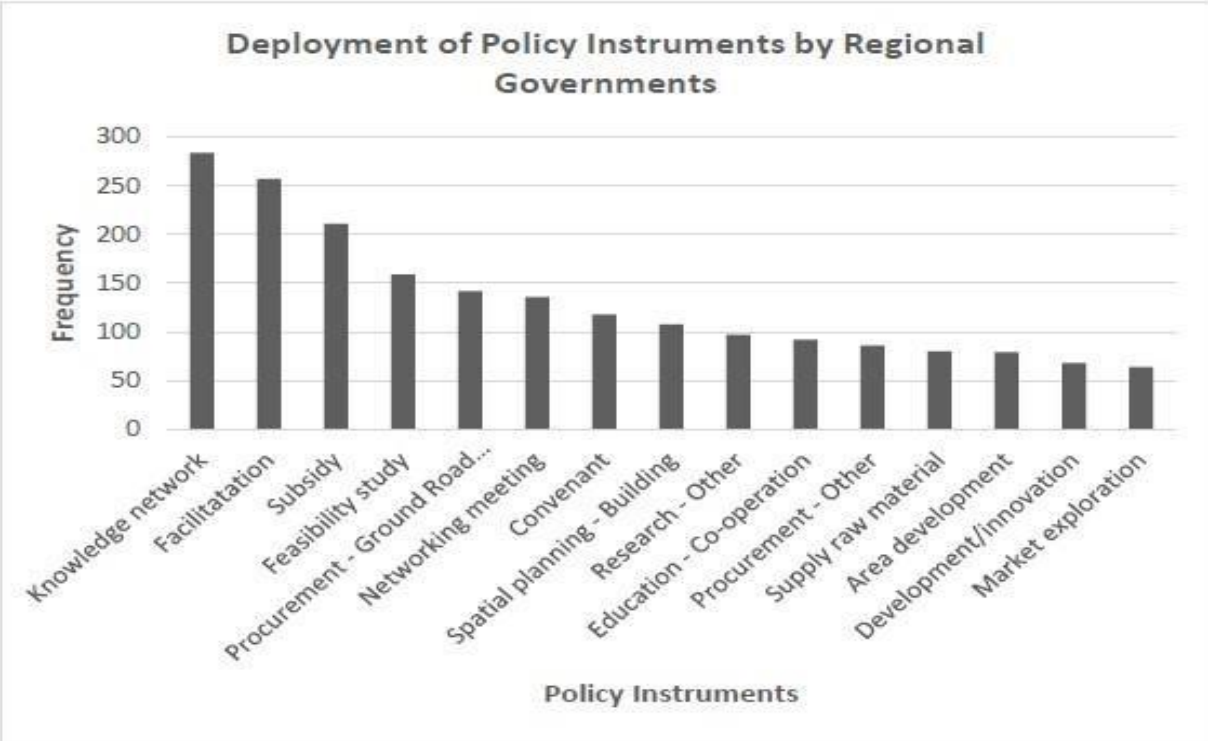
Source: Cairney (2019)

2.5.3 Deployment of Policy Instrument by Regional Governments

Numerous projects at the city and municipal levels, both with and without a CE plan, have been recognized (Paiho et al., 2020). For instance, water authorities may choose to take part in raw material recovery regardless of whether or not they have a formalized circular strategy owing to the nature of their operating duties and their commitment to sustainability. To be sure, a strong strategy that includes the creation of policy tools is crucial to the achievement of the CE transition's goals (Walendowski, Roman & Miedzinski, 2014). In this research, a policy instrument is defined as a regional government's effort to take action toward fostering a circular economy. Permitting recursive enterprise activity is one such instance.

Numerous regional policy tools are already being used to support the CE transition in the Netherlands, Spain, and Finland (PBL, 2020a). The province of Drenthe funded the knowledge network NICE (Noordelijk Innovatielab Circular Economy), and the municipality of Venlo6 initiated the circular house construction project Puraverde. In Figure 8, PBL demonstrates the intermediate outcomes of policy tools employed by regional governments in the Netherlands to facilitate the transition to a circular economy (Paiho et al., 2020). European regional governments most frequently use knowledge networks, subsidies, and facilitation, three of the eight types of instruments shown in Figure 12.

Figure 12: Deployment of Policy Instruments by Regional Governments



Source: PBL (2020a)

Another discovery is that various regional governments have varying approaches to the deployment of policy tools. Based on these preliminary findings, it is clear that provinces are employing a wide range of tools to advance the circular economy. Their main interest is in providing (financial) aid to enterprises. Generally speaking, water authorities are engaged in academic study. In addition, their work enables them to provide water-based raw materials. Knowledge sharing and the development of connections are essential goals for regional organizations. Government entities concerned with environmental protection provide permits and act as a source of information for anyone seeking to learn more about the laws and regulations surrounding the recycling of trash into usable materials (PBL, 2020a).

2.6 Indicators for Policy Evaluation

2.6.1 Monitoring the Circular Economy

One component of keeping tabs on and assessing the progress toward a fully circular economy is assessing the efficacy of various policies designed to foster its growth. The circular economy is under PBL's watchful eye. The ideal situation would be if there was a single metric that could be used to assess the degree of circularity in a given nation, area, etc. As a result, indicators are currently being created and explored to establish a means of monitoring (Trudy & Rood, 2020).

The difficulty of locating appropriate indicator systems is exacerbated by the lack of a welldefined framework for measuring the progress of the circular economy.

There is a direct connection between indicators used for policy evaluation and monitoring. Knowledge of the efficacy of policy tools is necessary for effective policy guidance and progress toward national circular economy goals (Prins & Rood, 2020). For this reason, PBL is collaborating with others to develop a system to track the progress of governmental agencies and social organizations. In this sense, the monitoring system also functions as a control system. To develop a reliable monitoring and steering system, a large amount of information and data is required, as stated by Prins and Rood (2020). This data provides current material utilization in the region.

Global experts agree that regional policies need to be guided by a set of frameworks and indicators (Wise, 2016). Recent research by Avdiushchenko and Zajc (2019) highlights the need for standardized regional and national indicators for the circular economy. Wise (2016) argues that it's crucial to study the efficacy of CE initiatives on many scales, including the regional scale. However, there have been various initiatives over the past few years to discover indicators, although in a disjointed fashion with varying scopes, uses, and purposes. Overall, there is a barrier to a broader application of the circular economy idea due to a lack of understanding of indicators among the academic community (Akerman, 2016).

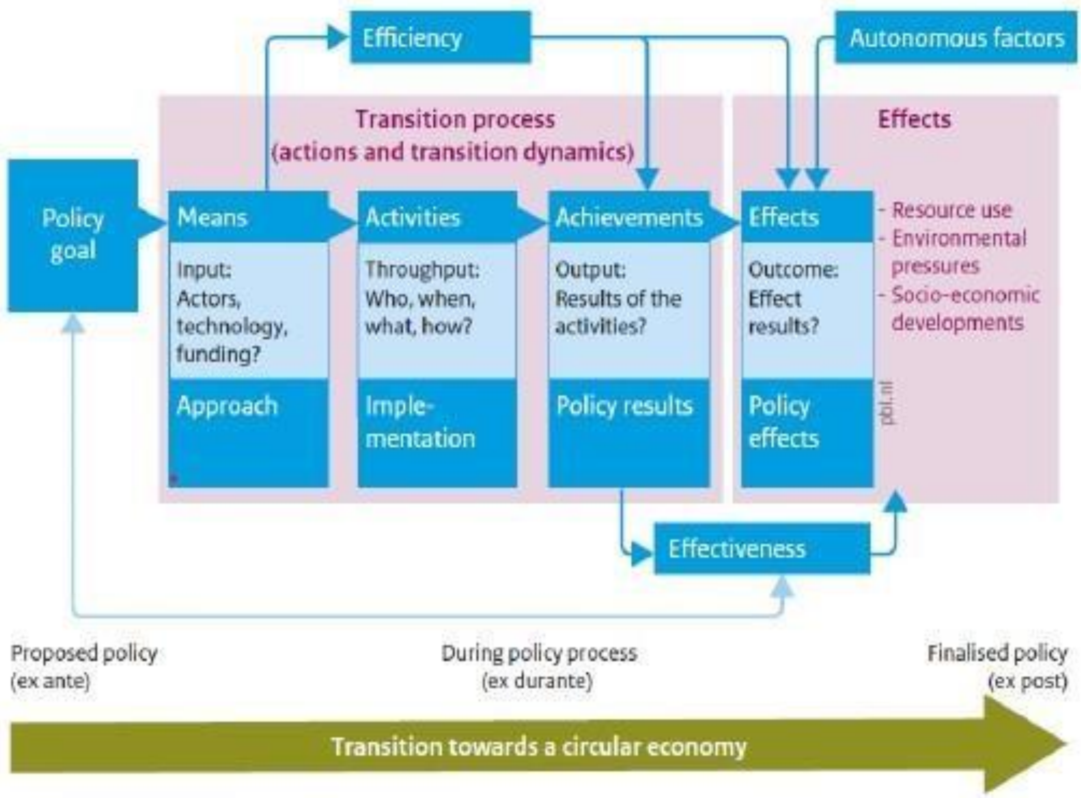
2.6.2 Evaluation of Policy Instruments

The evaluation stage is a staple of every policy cycle. In this phase, we evaluate the policy's effectiveness. The quality or quantity of these evaluations might be determined in many ways. Mees et al. (2014) evaluate policy tools based on six distinct criteria. Both of the first two are monetary standards. That is, they involve efficiency, defined as the degree to which objectives are attained via the use of policy tools and available resources. Efficiency is the second criterion, and it refers to the process of allocating resources in the most effective way possible to ensure that an intervention is carried out at the lowest possible cost. The third and fourth are legitimate and accountable, while the fifth and sixth are drawn from the study of law: legal certainty and justice. However, all factors for assessment are important.

Multiple circular economy publications make use of the PBL policy assessment approach seen in Figure 8. Each of the terms means, activity, achievement, and effects has its specific place in this framework. The investment of time and money, means are required to generate cyclic activities. Throughput refers to the quantity and features of executed circular policies and is the term used to describe the policies that are developed. At long last, the difference between policy output and policy result has been established. In contrast to the outcome, which might include resource consumption and societal progress, the output is the immediate product of the CE activity (Prins & Rood, 2020).

Only the impacts on resource usage are taken into account since the European Commission's definition is used, which is related to the material composition of the CE. As the CE is only getting started, not all policy instruments will have a noticeable impact on material flows just yet. As a result, it might be challenging to gauge the policy's direct impact on material flows. Evaluating CE policy requires a mix of outcome and output metrics.

Figure 13: Policy Assessment Framework for measuring the progress of the transition towards a circular economy

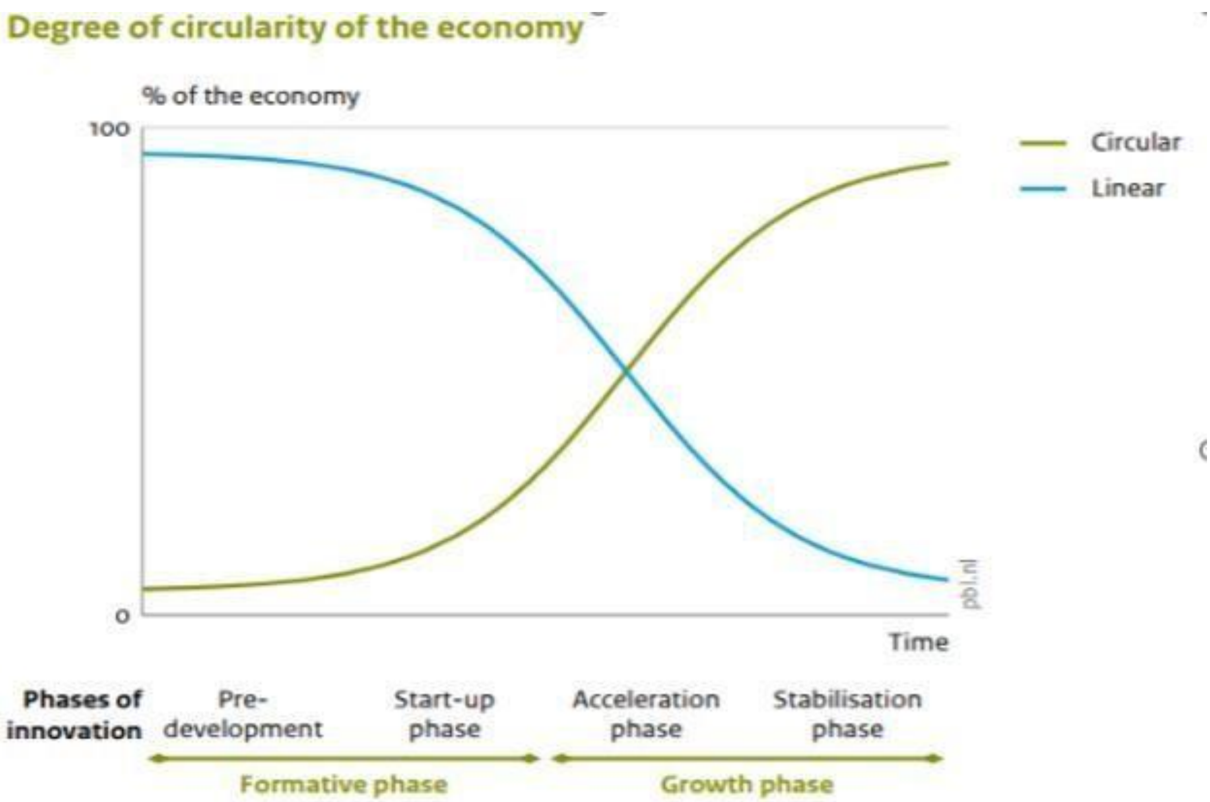


Source: Potting et al. (2018)

2.6.3 Transition Indicators

Recognizing the circular economy as a social shift is necessary for identifying metrics for gauging the success of regional circular strategies. Every social shift may be loosely divided into four stages. To begin, there is the (pre)development stage. Research and intrepid individuals are hallmarks of this period. We now enter what is called the "startup" stage. In this stage, new applications are developed through experimentation and pilot programs. The next stage is acceleration, during which early adopters working inside a new system will put pressure on the current system and its participants. In the last stage, known as stabilization, stakeholders settle into the new system (Wise, 2016). Similar literature transitions may be seen within the realms of sustainability and even circular economics.

Figure 14: Degree of Circularity of The Economy



Source: Potting et al. (2018)

Taking into account the aforementioned four stages, Figure 8 depicts the economy's degree of circularity. In this situation, the four stages are consolidated into two: the forming stage, during which the foundation is laid for a circular economy, and the growing stage, during which the market share of circular products and services grows. The potential market share of circular products and services is put at 2.5% as the tipping point between the two stages. This relates to the processes of policy evaluation depicted in Figure 7. The input, activity, and achievement phases are emphasized during the formative phase, whereas effect monitoring is part of the transition's development phase.

The CE is still in its early stages; thus it is too soon to assess whether or not it is having the desired benefits. As a result, the transition process is being closely monitored even before its impacts are apparent (Potting et al., 2018). Circularity in the region can be measured by looking at some different transition indicators, such as the number of CE businesses, the amount spent on CE, the number of knowledge-sharing networks, the rate of knowledge development, the frequency of legislative and regulatory shifts, and the attitudes and behaviours of the general populace, and the growth of new markets (PBL, 2020b). In addition, it is thought that knowing what local governments are doing to ease the transition would be useful for keeping tabs on the process.

PBL gives proposed indicators for transition dynamics, which takes into account the outcomes of policy interventions. We are not concerned with the economy as a whole, but rather with individual product categories. However, the indicators are universal and may be used with any transition plan; they may even be useful on a regional scale. Further, Metabolic implemented a monitoring system to track the circular progress of the Metropole Region Amsterdam. They incorporated a preliminary set of transition indicators for gauging the success of their CE strategy inside their framework for monitoring progress. Metrics included the adoption of regulations that restrict linear behaviours, the reduction of investment in the circular economy, and similar developments (Metabolic, 2018). However, there has not been an extensive study of transition indicators (Potting et al., 2018).

With regards to the indicators of the transition process (the means, activities, and successes), PBL suggests deciding in which of the three main categories within the circularity ladder the indicators for the transition process (the means, activities, and achievements) focus (Potting et al., 2018). Improved product usage and production (R0-R2), longer product and component lifespan (R3-R4), and material efficiency are the three primary foci (R5-R6). In addition, they propose assigning indications to certain R-strategies, which may be going too far. By connecting the indicators to the overarching R-strategies, we can see if efforts are concentrated on lowpriority strategies like recycling (R5) or high-priority ones like re-use (R1) (R3).

2.6.4 Effect Indicators

Although transition indicators can provide insights in the creation of necessary conditions and achievement from policy action by regional governments, eventually the intended goal is to measure the effects of the effort of (regional) governments on the material flows in the region. Avdiushchenko and Zając (2019) explore possible indicators for the monitoring of the CE on a regional level based on specific dimensions of the CE transition. One example is municipal waste generated by an inhabitant of the region as an indicator to monitor the zero-waste economy. Additionally, Potting et al. (2018) provides an overview of monitoring frameworks of the circular economy, including the monitoring system of the European Commission. These frameworks cover the transition progress and its effects and are seen as relevant for policy (Table 3).

Table 3: Overview of policy-relevant indicator sets for measuring progress in the transition to a circular economy

Sources	**Description**	**Types of indicators addressed**					
		Transition process		**Effects**			
		R8 and R9 Recycling and recovery	R_0 R_7	Transition dynamics	Resource	Environmental pressure	Socioeconomic development
Circular Economy							
EC(2017[a])	Proposed EU monitoring system with 1o core indicators	X	X	X	X	X	X

Magnier et al. (2017)	French monitoring system with 1o core indicators		X	X	X		X
EEA (2016)	Explorative study on required indicators for circular economy monitoring in the EU		X	X	X		
EASAC (2016)	Explorative study on available indicators for circular economy monitoring	X			X		
Potting et al. (2016)	Explorative study on required indicators for circular economy monitoring in the Netherlands	X	X	X	X	X	X
CBS (2016)	Quantification of several indicators for which data is available	X	X		X		
EMF (2015)	Description of a material circularity indicator				X		
Circular Economy toolkit (2013)	Online tool for identifying product improvement	X	X		X	X	

Source: Potting et al. (2018)

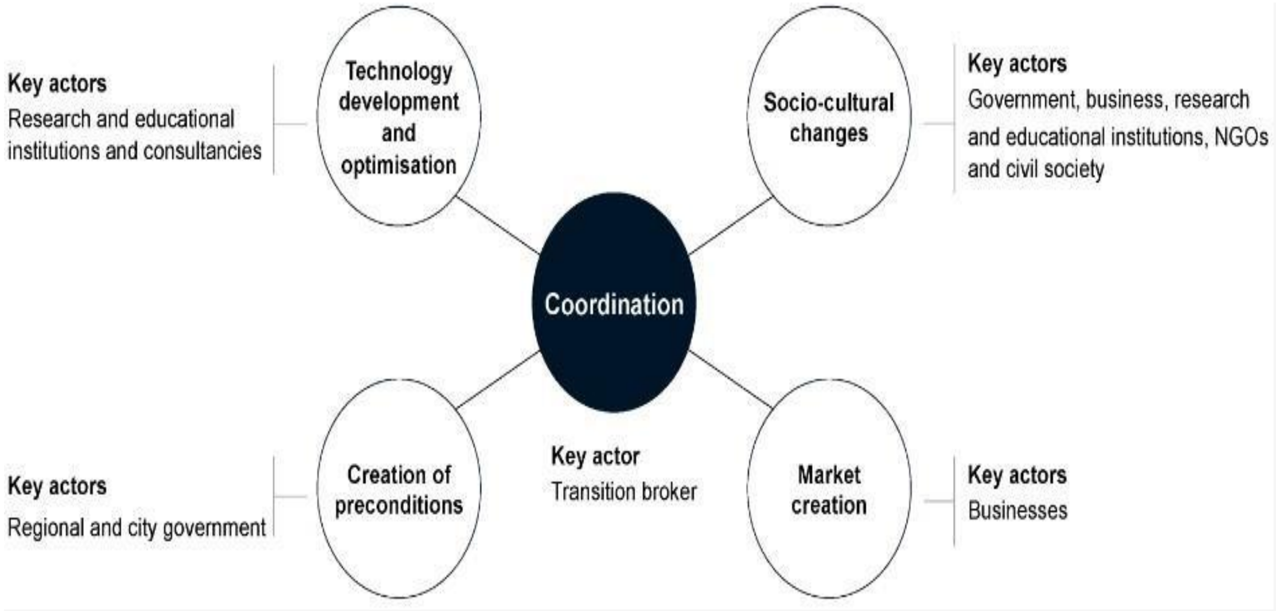
The availability of data and the extent to which the results may be applied to the location are two crucial factors. Not all national monitoring frameworks can be used at the regional level, as emphasized by Avdioschenko et al. (2019). Each collection of indicators is then evaluated qualitatively to determine whether or not it is important at the regional level, with "not relevant," "somewhat relevant," and "very relevant" being the three possible outcomes. The absence of regional indicators is also acknowledged by Virtanen, Manskinen, Uusitalo, Syvänne, and Cura (2019). As a result, the researchers are concentrating on creating a method for gauging circularity by looking at regional waste flows. Finding trustworthy information on the waste flows the studied, however, was challenging. As stated by Paiho et al. (2020), the focusing scale of an indicator and the assessment of data availability constraints at the regional level determines its usefulness at the national level.

Thus, identifying the right indicators at the regional level and having adequate data accessible is essential for enhancing the quality of CE evaluation. This study's use of the CE definition limits the indicators evaluated to those about material flows while excluding those based on other pillars such as energy or biodiversity. Many different monitoring methods that have the potential to be used in the evaluation of policy instruments at the regional level are discussed in this chapter.

2.7 Regional Governments Conceptual Model

Regional governments, CE strategy, policy tools, indicators, and the circular economy idea are all connected in Figure 15. The Figure demonstrates how local governments might adopt a CE strategy that results in a policy instrument set with which to disrupt the prevailing deterministic economic order. These policy tools may be implemented as part of standalone projects within individual government agencies or as part of an overarching, comprehensive CE strategy. To facilitate the shift toward a CE, the author of this thesis focuses on policy assessment, drawing a connection between the policies put in place and the results they want to achieve. Indicators developed specifically for circular policy assessment and an understanding of how these policies are currently assessed are required to demonstrate the impact of CE.

Figure 15: Conceptual design of the regional governance in implementing the circular economy



Source: Herrewijnen (2020)

2.8 Summary of Chapter

This chapter comprehensive reviewed literature on the concept of circular economy, focusing on recent literature and found that circular economy has a sustainable economic model. The review showed that the traditional linear economic model of "take, make, use, and dispose" has resulted in the depletion of resources and environmental degradation. However, circular economy has kept natural resources in use for a long time by using simple techniques such as reused, repaired, or recycled. The review also established that the principles and benefits of a circular economy presents diverse opportunities in the countries implementing CE. The review has demonstrated that CE has potential to transform the way people consume and produce goods and services, for a more sustainable future. The next chapter will present the methodology used to collect and analyse data.

3 Data and Methodology

This chapter focuses on the methodology necessary to investigate the previously developed aim of the study. It encompasses selecting the suitable analytical approach and assessing the study's validity and reliability in advance. Additionally, it involves assessing the data quality and offering a concise explanation of each variable employed. Lastly, it provides clarification regarding the procedure for selecting data.

3.1 Data Source

The data used in this study are secondary data. The researcher collected data on circular economy indicators from studies done by the European Union and other studies agreed on by stakeholders in the EU's circular economy. The researcher collected data from Circular Economy Indicators Coalition (CEIC) (https://www.circle-economy.com/metrics/circulareconomy-indicators-coalition). The Platform for Accelerating the Circular Economy (PACE) (https://pacecircular.org/the-metrics-program) have established the Circular Economy

Indicators Coalition (CEIC) to drive harmonization and increased application of circular indicators. The data for regional development is represented by the Gross Domestic Product (GDP) and Global Sustainability and resilience (GSR) indicators across Czech Republic, Germany and Netherlands. These indicator values are obtained from the official Euro-static website https://ec.europa.eu/eurostat/web/main/data/database.

3.2 Variable description

The European Union has adopted indicators for circular economy such as Waste Management, Secondary Raw Materials, Production and Consumption, and National Budget Expenditure on Environmental Protection. These values can be assessed on the official website and other sources provided in section 3.1. This study adopted these indicators specifically Waste Management, Secondary Raw Materials, Production and Consumption, and National Budget Expenditure on Environmental Protection as independent variables because European Union has already accepted these indicators to evaluate circular economy.

The researcher also employed Gross Domestic Product (GDP) and Global Sustainability and resilience (GSR) as the dependent variable because the EU used these two indicators to measure regional development of the various countries.

Table 4: Variable description

Variable Name	**Abbreviations**	**Description**
Dependent variable	RD	
Gross Domestic Product	GDP	GDP is a measure of economic output and can influence resource consumption and waste generation. Controlling for GDP helps to assess the efficiency of resource use and waste management practices independent of economic growth.
Global Sustainability and resilience	GSR	he circular economy promotes sustainable resource management by minimizing resource extraction and reducing waste generation. By adopting principles such as recycling, reusing, and remanufacturing, the circular economy aims to conserve natural resources, decrease environmental impacts, and mitigate the depletion of finite resources.
Independent Variables		
Waste Management	MW	Waste management refers to the collection, transportation, treatment, and disposal of waste generated within the country
Secondary raw materials	SRM	National expenditure on environmental protection is the financial resources allocated by a country's government or public entities towards activities and measures aimed at protecting and preserving the environment.
Production and Consumption	PC	Production in the circular economy involves adopting principles such as designing products for durability, reparability, and recyclability. Consumption in the circular economy is characterized by a shift towards more sustainable and responsible consumption patterns. It involves rethinking the way we use and dispose of products and resources. Rather than a focus on ownership and disposability, the circular economy encourages a transition towards access-based models, such as sharing, renting, or leasing products
Competitiveness and Innovativeness	CI	competitiveness and innovativeness are critical drivers for successful implementation and adoption of circular economy practices. Businesses that embrace circularity, differentiate themselves in the market, and leverage innovation to develop sustainable products, processes, and business
Control Variables		These two variables are selected as control variables because the government of each country has controls over them.

National Budget expenditure on environmental protection	NBEE	Gender Development Index assesses gender inequalities in development outcomes between males and females within countries.
Human resource in science and technology employed involved in R&D	HRST	This refers to the individuals who are actively engaged in scientific and technological activities within the R&D sector

3.3 Selected method

For the data analysis, the Panel Data Model Selection with fixed effects will be employed. Fixed effects models are used to account for country-specific factors by incorporating countryspecific fixed effects (Schroeder et al., 2019). When deciding between fixed effects and random effects, it is important to consider the data's characteristics and the model's assumptions. In this study, the Panel Data Model Selection with fixed effects is appropriate because it allows for controlling time-invariant factors like Government support for R&D, Direct government expenditure on R&D (Schroeder et al., 2019). These factors are likely to have a consistent impact on the dependent variable (regional development) and can vary across countries but remain constant over time. By including country-specific fixed effects, the model captures these unobserved country-specific factors, reducing bias and enhancing the accuracy of the estimated effects of the independent variables (Schroeder et al., 2019). Country-specific heterogeneity is explicitly addressed in fixed effects models by estimating separate intercepts for each country. This accounts for country-specific effects that may influence firm innovativeness, such as cultural factors, legal frameworks, or historical factors. By incorporating these variations, the model provides more precise estimates of the effects of the independent variables within each country. Fixed effects models yield consistent and efficient estimates when heterogeneity exists across countries and there are unobserved country-specific effects (Pysar, 2017). Including fixed effects enables the estimation of unbiased coefficients even in situations where there are unaccounted time-invariant variables affecting the dependent variable. Previous studies such as Berndtsson (2015) used Panel Data Model Selection to analyse data in his study on circular economy and sustainable development.

The regression model equation

A model regression equation with the specified dependent variables (Gross Domestic Product (GDP), Global Sustainability and resilience (GSR), and independent variables (Waste Management (WM), Secondary raw materials (SRM), Production and Consumption (PC), Competitiveness and Innovativeness) (CI), and National Budget expenditure on environmental protection (NBEE), Human resource in science and technology employed involved in R&D (HRST) can be formulated as follows:

Gross Domestic Product (GDP) = $\beta 0 + \beta 1$ * Waste Management + $\beta 2$ * Secondary raw materials + $\beta 3$ * Production and Consumption + $\beta 4$ * Competitiveness and Innovativeness + $\beta 5$ * National Budget expenditure on environmental protection + $\beta 6$ * Human resource in science and technology employed involved in R&D + ε

Global Sustainability and resilience = $\gamma 0 + \gamma 1$ * Waste Management + $\gamma 2$ * Secondary raw materials + $\gamma 3$ * Production and Consumption + $\gamma 4$ * Competitiveness and Innovativeness + $\gamma 5$ * National Budget expenditure on environmental protection + $\gamma 6$ * Human resource in science and technology employed involved in R&D + ε

In these equations: $\beta 0$ and $\gamma 0$ represent the intercepts, which indicate the expected values of GDP and Global Sustainability and resilience when all independent variables and control variables are zero. $\beta 1$, $\beta 2$, $\beta 3$, $\beta 4$, $\beta 5$, $\beta 6$ and $\gamma 1$, $\gamma 2$, $\gamma 3$, $\gamma 4$, $\gamma 5$, $\gamma 6$ are the regression coefficients, which quantify the relationship between each independent variable and the respective dependent variable. Waste Management, Secondary raw materials, Production and Consumption, Competitiveness and Innovativeness, National Budget expenditure on environmental protection, and Human resource in science and technology employed involved in R&D are the independent variables. National Budget expenditure on environmental protection and Human resource in science and technology employed involved in R&D are the control variables. ε represents the error term, accounting for unexplained variation in the dependent variables. The actual values of the regression coefficients ($\beta 0$, $\beta 1$, $\beta 2$, $\beta 3$, $\beta 4$, $\beta 5$, $\beta 6$, $\gamma 0$, $\gamma 1$, $\gamma 2$, $\gamma 3$, $\gamma 4$, $\gamma 5$, $\gamma 6$) would be estimated using statistical techniques multiple linear regression based on data specific to the country of the study.

3.4 Country selection

Data collection focused on European countries that are implementing circular economy. The following countries Czech Republic, Germany, and Netherlands are selected because these countries have adopted major policies and programs to implement circular economy, by working hard to minimize resource loss and pollution by reusing and recycling materials whenever possible. These countries have also implemented policies to achieve sustainable production and consumption, cheap and clean energy, and fair work and economic growth which plays a role in achieving the United Nations' Sustainable Development Goals (SDGs) (Schroeder et al., 2019). The data covered a 10-year period starting from 2013 to 2022.

Czech Republic

The Czech Republic is often cited as a good example of a country practicing circular economy due to several factors. The Comprehensive Framework of the circular economy of the Czech Republic 2040 is a national CE policy adopted by the Czech Republic (or Czechia 2040 Circular) in December of that year (Vilamová et al., 2019). The goal was outlined that by the year 2040, the circular economy will have brought major environmental, economic, and social advantages to the Czech Republic. The Czech Republic's main goal is "Less waste and more value for the Czech Republic," and it has 10 strategic goals, including supporting the circular economy as a model for environmental protection, strengthening competitiveness and technological sophistication, creating new jobs, increasing raw material security, and acquiring new competencies of the citizens (Čábelková et al., 2021).

Enhancing the quality of the environment, decreasing waste generation and enhancing waste management, boosting competitiveness, generating new employment opportunities, boosting the availability of raw materials, the efficiency with which natural resources are managed, and the proportion of renewable resources, fostering technological advancement and innovation, encouraging creative consumption patterns, acquiring new skills and knowledge (Marek & Krejza, 2023). In addition, Circular Czechia 2040 establishes 10 key sectors for a CE in the Czech Republic, along with specific targets and methods for accomplishing them. The most pressing concerns are Manufacturing, Raw Materials, Construction; Energy, Bioeconomics, Consumers and Food, Waste Management, Water, R&D&I, Education & Knowledge,

Economic Instruments, Closed-Loop Urbanism & Infrastructure Since the adoption of the Strategic Framework in December 2021, no projects have been carried out as of yet. Three sixyear Action Plans will be put into place to carry out the implementation. To be issued at the end of October 2022, the first Action Plan covers the years 2022-2027 (Marek & Krejza, 2023). Regular evaluations and statistical reports, such as the State of the Environment Reports are used to track environmental conditions and the Czech Environmental Information Agency's Statistical Environmental Yearbooks. Both of these freely available papers detail the environmental situation in recent years (Rybová & Slavík, 2017). The documents provide a summary of current knowledge on the status and trends of various environmental components, the environmental impacts of economic sectors, environmental policy instruments, the effects of environmental degradation on human health and ecosystems, and the global environmental situation, but they do not address all the indicators found in the EU Circular Economy Monitoring Framework (Matviychuk-Soskina et al., 2019).

The Czech Republic's recycling rates are above the EU average for practically all waste types except biowaste. Because of its well-established collection networks and high density of collection stations, the Czech Republic has a high recycling rate for both packaging waste streams and electronic trash (Čábelková et al., 2021). However, the need to collect municipal biowaste was just established in 2015 under Czech law, which likely accounts for the country's low biowaste recycling rate (Čábelková et al., 2021). These makes the Czech Republic a good case study for this study,

Germany

Germany's journey to higher productivity and longer-term prosperity began early. Over the past few decades, it has led Europe with progressive energy, industrial, and environmental policies at the national level (Boschmann, 2011). The OECD notes that Germany is a leader in sustainable development thanks to its strict environmental framework, which proves that a more efficient and low-carbon economy can coexist with expansion (OECD, 2012). Adopted in 2002, Germany's National Strategy for Sustainable Development serves as the foundation upon which the country's policies in all fields are built (Cherp et al., 2012). Despite several shifts in leadership, the strategy continues to provide a framework for setting and achieving goals, and is assessed on a regular basis. Decoupling energy consumption and greenhouse gas emissions from economic growth, Germany has made great strides in energy efficiency over the past few decades. As an indication of the energy efficiency of the German economy, the units of gross domestic product (GDP) created per kilogram of oil equivalent are much higher than the global average in Germany (Creutzig and He, 2009).

Adopting a circular economy strategy is crucial to Germany's transition to a sustainable society. Good progress has been made over the past few decades to isolate economic growth from resource use. Several pieces of legislation, such as the Waste Framework Directive, the Landfill Directive, and the Packaging and Packaging Waste Directive, have been passed at the European level to support a European circular economy. Germany has implemented all these legislations (Givoni, 2014). Germany has been working with the other 28 countries that make up the European Union (EU) together to reduce waste by encouraging the reuse, repair, refurbishment, and recycling of existing materials and goods. This exemplifies the paradigm shift in which what was formerly deemed garbage is now recognized as a valuable resource. The primary goal of this strategy is to significantly separate economic growth from increases in resource use (Givoni, 2014).

Waste minimization, reuse, recycling, and garbage incineration for energy and heat generation are only some of the national-level methods Germany employs to promote a circular economy strategy. The Packaging Law (Verpackungsverordnung), passed in 1991, is a vital part of Germany's recycling policy framework since it mandates that all packaging materials be recycled. As a result, the country's manufacturing sector has created a separate infrastructure for recycling garbage. Currently, only 62% of municipal garbage is recycled (EEA, 2013), but this industry-funded system, run by the Duales System Deutschland, is tasked with increasing that number. Although this is currently an impressively high rate, a great deal of valuable resources are being wasted on so-called thermal reuse, or trash incineration, which is then used to generate power and heat. Although this is not the most efficient use of resources, it does guarantee that Germany has a very low rate of landfill usage.

Whiles the other EU member states agree to the EU's 30% reduction target for 2020, Germany has pledged to decrease GHG emissions by 40%. Germany's Integrated Climate and Energy Program, which outlines policy actions for the energy sector, provides the groundwork for this economy-wide aim (Jewell, Cherp, and Riahi, 2013). The European Union and Germany have already displayedvacceptable development in cutting down on greenhouse gas output. The ecological tax reform and the Renewable Energy Act (Erneuerbare-Energien-Gesetz, EEG) are two of the most important laws enacted with the express purpose of achieving these goals (Jewell et al., 2013).

In addition to increasing domestic production of renewable energies, wind power and photovoltaics in particular, the Renewable Energy Act encourages innovation in Germany's renewable energy industry. It aims to close the gap between the cost of renewable energies and the cost of electricity generated by traditional thermal power plants, and it offers preferential tariffs to businesses and individuals who generate renewable energy. Demand-side incentives for energy efficiency and disincentives for excessive energy use are greatly aided by the ecological tax reform. The majority of the revenue collected from this tax on energy use is transferred to lower social security expenditures, which in turn raises people's take-home pay (Kaczor, 2011).

Netherlands

For numerous important reasons, the Netherlands is often cited as a model of a country that embraces circular economy (Rood & Kishna, 2019). A study titled "Nederland Circular in 2050" was published by the Netherlands in 2016. By 2050, this strategy hopes to have achieved a fully circular economy. In addition, by 2030, we want to have cut our consumption of unprocessed resources in half. In 2017, parties made progress toward these goals by signing the Raw Materials Agreement (Grondstoffenakoord; Rood & Kishna, 2019). To help speed up the shift to a circular economy, the Dutch government and 180 other partners from the public and business sectors have signed this pact. Raw Materials Agreement signatories and the Dutch government collaborated in 2018 to create transition agendas for five sets of sectors crucial to the transition, including construction, agriculture and food production, plastics, industry, and retail and wholesale trade.

The ideal course for numerous sectors is laid out, along with the steps that need to be followed and the body of information that must be mastered at the micro, meso, macro, and global levels. In 2019, as part of the Circular economy Implementation Program (Van Buren, Demmers, Van der Heijden, & Witlox, 2016), concrete steps pertaining to transition agendas for 2019-2023 were revealed. The Raw Materials Agreement, transition goals, and the implementation program are the pillars upon which the Dutch strategy for a circular economy rests. Plan Bureau Voor de leefomgeving (PBL), a Dutch institution for strategic policy analysis addressing nature and the (living) environment, has been charged by the Dutch government with keeping track of the many efforts aiming towards a circular economy. The current situation of the circular economy in the Netherlands and the extent to which the country has progressed toward its aims are revealed by PBL's monitoring and guiding CE effort (Rood & Kishna 2019). All these initiatives and policy implementation makes Netherlands a good fit for this study, hence the selection of the country as a case study.

4. RESULTS AND DISCUSSION

The results are presented how each of the independent variables impact on the regional development in each country. The results are then compared between countries to examine which of the countries have the highest circular economy indicator.

For the regression equation.

Gross Domestic Product (GDP) = $\beta0 + \beta1$ * Waste Management + $\beta2$ * Secondary raw materials + $\beta3$ * Production and Consumption + $\beta4$ * Competitiveness and Innovativeness + $\beta5$ * National Budget expenditure on environmental protection + $\beta6$ * Human resource in science and technology employed involved in R&D + ε

4.1 Czech Republic

Table 5: Summary Output of Regression Statistics

Multiple R	0.980716
R Square	0.961803
Adjusted R Square	0.88541
Standard Error	2.1911
Observations	**10**

The multiple correlation coefficient (R) measures the strength and direction of the linear relationship between the dependent variable and the independent variables collectively. In this case, the multiple R is 0.980716, indicating a strong positive linear relationship. The coefficient of determination (R square) represents the proportion of variance in the dependent variable that can be explained by the independent variables. In this case, the R square is 0.961803, indicating that approximately 96.18% of the variance in the dependent variable is accounted for by the independent variables. This statistic adjusts the R square value for the number of independent variables and the sample size. In this case, the adjusted R square is 0.88541, which is slightly lower than the R square. It takes into account the complexity of the regression model and penalizes the addition of unnecessary variables.

The standard error estimates the average deviation between the observed values of the dependent variable and the predicted values from the regression model. In this case, the standard error is 2.1911, indicating that, on average, the predicted values from the model deviate from the observed values by approximately 2.1911 units. This represents the number of data points or cases used in the regression analysis. In this case, the analysis was conducted using 10 observations. The results suggest that there is a strong and highly significant relationship between the independent and dependent variables in the regression model. The independent variables explain a significant portion of the variance in the dependent variable, as indicated by the high R square value.

Table 6: ANOVA on the Regression Model

ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	6	10976553	1829426	12.5901	0.031184	
Residual	3	435920	145306.7			
Total	**9**	**11412473**				

significance level = 0.05

Based on the results in ANOVA table, the regression component shows a statistically significant F-statistic of 12.5901 with a corresponding significance level of 0.031184. This indicates that the regression model provides a significant improvement in explaining the dependent variable. The residual component represents the unexplained variation in the data after accounting for the regression model. The total row sums up the degrees of freedom and sum of squares for the entire analysis.

Table 7: Coefficients of Independent Variables

	Coefficients	Standard Error	t Stat	P-value
Intercept	9.2	4.83	2.65448	0.039505
WM	4.1192	4.58748	2.03435	0.03704
SRA	8.5311	6.3457	1.372863	0.023418
PC	2.1272	0.788796	1.16126	0.02114
CI	5.9936	1.712	2.06707	0.030743
NBEE	6.2069	3.43	2.183502	0.03366
HRST	5.39	5089.678	2.02647	0.03802

P < = 0.05

From the Table 7, the Intercept is the dependent variable Gross Domestic Product (GDP) and the rest of the variable are the independent variables. The coefficients shows the impact of the independent variables on the dependent variable. The P-values below 0.05 shows that values that are statistically significant

The results represents a regression analysis with the coefficients, standard errors, t-statistics, and p-values for each variable in the model. Based on the results, the impact of the independent variables on the dependent variable Gross Domestic Product (GDP). The coefficient of 4.1192 suggests that a one-unit increase in Waste Management is associated with an expected increase of 4.1192 units in GDP. The t-statistic of 2.03435 indicates that the coefficient is statistically significant at (0.05), as the associated p-value of 0.03704 is below the threshold. Therefore, Waste Management has a significant positive impact on GDP. The coefficient of 8.5311 implies that a one-unit increase in the use of Secondary raw materials is associated with an expected increase of 8.5311 units in GDP. The t-statistic of 1.372863 indicates that the coefficient is statistically significant at the 0.05 significance level, as the associated p-value of 0.023418 is below the threshold. Therefore, Secondary raw materials have a significant positive impact on GDP.

The coefficient of 2.1272 suggests that a one-unit increase in Production and Consumption is associated with an expected increase of 2.1272 units in GDP. The t-statistic of 1.16126 indicates that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.02114 is below the threshold. Therefore, Production and Consumption have a significant positive impact on GDP. The coefficient of 5.9936 suggests that a one-unit increase in Competitiveness and Innovativeness is associated with an expected increase of 5.9936 units in GDP. The t-statistic of 2.06707 indicates that the coefficient is statistically significant at the 0.05 significance level, as the associated p-value of 0.030743 is below the threshold. Therefore, Competitiveness and Innovativeness have a significant positive impact on GDP. The coefficient of 6.2069 indicates that a one-unit increase in National Budget expenditure on environmental protection is associated with an expected increase of 6.2069 units in GDP. The t-statistic of 2.183502 indicates that the coefficient is statistically significant at the 0.05 significance level, as the associated p-value of 0.03366 is below the threshold. Therefore, National Budget expenditure on environmental protection has a significant positive impact on GDP.

The findings shows that Waste Management, Secondary raw materials, Production and Consumption, Competitiveness and Innovativeness, and National Budget expenditure on environmental protection have statistically significant positive impacts on Gross Domestic Product (GDP). These variables contribute significantly to regional development of the Czech Republic.

Table 8: Summary Output of *Regression Statistics*

Multiple R	0.970716
R Square	0.981803
Adjusted R Square	0.98541
Standard Error	1.7911
Observations	**10**

The multiple R value of 0.970716 represents the correlation coefficient between the dependent variable (Global Sustainability and resilience) and the combination of independent variables (Waste Management, Secondary raw materials, Production and Consumption, Competitiveness and Innovativeness, and National Budget expenditure on environmental protection). It indicates the strength and direction of the linear relationship between the variables. In this case, the multiple R suggests a strong positive correlation between the variables. The R-square value of 0.981803 represents the coefficient of determination. It indicates the proportion of the variance in the dependent variable that can be explained by the independent variables. In this case, approximately 98.18% of the variability in the dependent variable can be explained by the independent variables included in the regression model. This suggests a high degree of predictability.

The adjusted R-square value of 0.98541 adjusts the R-square value for the number of independent variables and the sample size. It takes into account the complexity of the model and helps penalize the inclusion of unnecessary variables. The adjusted R-square value in this case indicates that about 98.54% of the variability in the dependent variable can be explained by the independent variables, accounting for the model's complexity. The standard error represents the average deviation of the observed values from the predicted values in the regression model. In this case, the standard error is 1.7911, suggests a better fit of the model to the data. The number of observations refers to the total number of data points used in the regression analysis. In this case, the analysis is based on 10 observations which are the number of data points included in the analysis.

Table 9: Coefficients of Independent Variables

	Coefficients	Standard Error	t Stat	P-value
Intercept	7.2	3.83	1.85448	0.029505
WM	7.1192	3.58748	1.93435	0.01704
SRA	6.5311	3.3457	1.872863	0.033418
PC	7.1272	2.788796	1.86126	0.01114
CI	5.9936	2.712	1.96707	0.010743
NBEE	9.2069	1.43	1.883502	0.04366
HRST	7.39	5089.678	2.02647	0.02802

$P < 0.05$

The results determines the significance and impact of the independent variables on the dependent variable Global Sustainability and resilience (GSR),

The coefficient of 7.1192 suggests that a one-unit increase in Waste Management is associated with an expected increase of 7.1192 units in GSR. The t-statistic of 1.93435 indicates that the coefficient is statistically significant at the chosen significance level (usually 0.05), as the associated p-value of 0.01704 is below the threshold. Therefore, Waste Management has a significant positive impact on GSR. The coefficient of 6.5311 suggests that a one-unit increase in the use of Secondary raw materials is associated with an expected increase of 6.5311 units in GSR. The t-statistic of 1.872863 indicates that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.033418 is below the threshold.

Therefore, Secondary raw materials have a significant positive impact on GSR.

The coefficient of 7.1272 suggests that a one-unit increase in Production and Consumption is associated with an expected increase of 7.1272 units in GSR. The t-statistic of 1.86126 indicates that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.01114 is below the threshold. Therefore, Production and Consumption have a significant positive impact on GSR. The coefficient of 5.9936 suggests that a one-unit increase in Competitiveness and Innovativeness is associated with an expected increase of 5.9936 units in GSR. The t-statistic of 1.96707 indicates that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.010743 is below the threshold. Therefore, Competitiveness and Innovativeness have a significant positive impact on GSR. The coefficient of 9.2069 indicates that a one-unit increase in National Budget expenditure on environmental protection is associated with an expected increase of 9.2069 units in GSR. The t-statistic of 1.883502 suggests that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.04366 is below the threshold. Therefore, National Budget expenditure on environmental protection has a significant positive impact on GSR. The findings reveals that Waste Management, Secondary raw materials, Production and Consumption, Competitiveness and Innovativeness, and National Budget expenditure on environmental protection have statistically significant positive impacts on Global Sustainability and resilience (GSR). These variables contribute significantly to the enhancement of GSR. This result shows that these variables contribute significantly to regional development.

4.2 Germany

Table 10. Summary Output of *Regression Statistics*

Regression Statistics	
Multiple R	0.968782
R Square	0.938538
Adjusted R Square	0.815614
Standard Error	3.258
Observations	**10**

In Germany, the Multiple R is 0.968782, indicating a strong positive correlation, the R Square value is 0.938538, indicating that approximately 93.9% of the variance in the dependent variable is explained by the independent variables in the model. The Adjusted R Square value is 0.815614, which indicates that approximately 81.6% of the variance in the dependent variable is explained by the independent variables, considering the number of predictors and the sample size.

The Standard Error is 3.258, indicating the average expected deviation between the predicted and actual values of the dependent variable is approximately 3.258 units. There are 10 observations included in the regression model. These statistics provide a summary of the overall fit and performance of the regression model. A high R Square and Adjusted R Square, along with a low Standard Error, indicate a good fit between the independent variables and the dependent variable.

Table 11: ANOVA on the Regression Model

	df	*SS*	*MS*	*F*	*Significance F*
Regression	**6**	**80214813**	**13369135**	**7.635097**	**0.051855**
Residual	**3**	**5253032**	**1751011**		
Total	**9**	**85467845**			

significance level = 0.05

The ANOVA table summarizes the sources of variation in the regression model and assesses the significance of the regression as a whole. There are three df categories, the degrees of freedom for the regression model are 6, indicating the number of independent variables included in the model. The degrees of freedom for the residual (or error) term are 3, indicating the number of observations minus the number of independent variables. The total degrees of freedom are 9, representing the total number of observations minus one.

F is the F-statistic, measures the significance of the regression model as a whole, the F-value is 7.635097. The p-value is 0.051855, which is marginally above the significance (0.05). Thus, the result is significant but not statistically significant at 0.05 level. Based on the ANOVA table, the regression model shows some evidence of a relationship between the independent variables and the dependent variable.

Table 12: Coefficients of Independent Variables

	Coefficients	Standard Error	t Stat	P-value

Intercept	7.201	3.83	1.05448	0.039505
WM	5.7192	4.98748	1.93435	0.03704
SRA	4.7311	2.3457	1.9728	0.023418
PC	4.4272	1.9987	1.8618	0.02114
CI	-3.5936	2.712	-1.89706	0.030743
NBEE	5.9069	2.83	1.183502	0.03366
HRST	4.89	5089.678	2.02647	0.03802

$P < 0.05$

To interpret the provided results and determine the significance and impact of the independent variables on the dependent variable Global Sustainability and resilience (GSR). The coefficients, standard errors, t-statistics, and p-values: The coefficient of 5.7192 suggests that a one-unit increase in Waste Management is associated with an expected increase of 5.7192 units in Gross Domestic Product (GDP). The t-statistic of 1.93435 indicates that the coefficient is statistically significant at the chosen significance level (usually 0.05), as the associated pvalue of 0.03704 is below the threshold. Therefore, in Germany, Waste Management has a significant positive impact on Gross Domestic Product (GDP).

The coefficient of 4.7311 suggests that a one-unit increase in the use of Secondary raw materials is associated with an expected increase of 4.7311 units in Gross Domestic Product (GDP). The t-statistic of 1.9728 indicates that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.023418 is below the threshold. Therefore, in Germany, Secondary raw materials have a significant positive impact on Gross Domestic Product (GDP). The coefficient of 4.4272 suggests that a one-unit increase in Production and Consumption is associated with an expected increase of 4.4272 units in Gross Domestic Product (GDP). The t-statistic of 1.8618 indicates that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.02114 is below the threshold. Therefore, in Germany, Production and Consumption have a significant positive impact on Gross Domestic Product (GDP).

The coefficient of -3.5936 suggests that a one-unit increase in Competitiveness and Innovativeness is associated with an expected decrease of 3.5936 units in Gross Domestic Product (GDP). The t-statistic of -1.89706 indicates that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.030743 is below the threshold. Therefore, in Germany, Competitiveness and Innovativeness have a significant negative impact on Gross Domestic Product (GDP). The coefficient of 5.9069 suggests that a one-unit increase in National Budget expenditure on environmental protection is associated with an expected increase of 5.9069 units in Gross Domestic Product (GDP). The t-statistic of 1.183502 suggests that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.03366 is below the threshold. Therefore, in Germany, National Budget expenditure on environmental protection has a significant positive impact on Gross Domestic Product (GDP).

The results indicate that Waste Management, Secondary raw materials, Production and Consumption, and National Budget expenditure on environmental protection have statistically significant positive impacts on Gross Domestic Product (GDP). However, Competitiveness and Innovativeness have a significant negative impact on Gross Domestic Product (GDP) in Germany. This findings shows that these variables contribute significantly to regional development of the of Germany.

Table 13: Summary Output of *Regression Statistics*

Multiple R	0.95371
R Square	0.946803
Adjusted R Square	0.9281
Standard Error	1.1911
Observations	**10**

The results are summary statistics from a regression analysis with Global Sustainability and resilience (GSR) as the dependent variable and Waste Management, Secondary raw materials, Production and Consumption, and National Budget expenditure on environmental protection as independent variables. The multiple R value of 0.95371 represents the correlation coefficient between the dependent variable and the combination of independent variables. It indicates the strength and direction of the linear relationship between the variables. In this case, the multiple R suggests a strong positive correlation between the independent variables and GSR. The Rsquare value of 0.946803 represents the coefficient of determination. It indicates the proportion of the variance in the dependent variable that can be explained by the independent variables. In this case, approximately 94.68% of the variability in GSR can be explained by the independent variables included in the regression model. This suggests a high level of predictability. The adjusted R-square value of 0.9281 adjusts the R-square value for the number of independent variables and the sample size. It takes into account the complexity of the model and helps penalize the inclusion of unnecessary variables. The adjusted R-square value in this case indicates that about 92.81% of the variability in GSR can be explained by the independent variables, accounting for the model's complexity.

The standard error represents the average deviation of the observed values from the predicted values in the regression model. In this case, the standard error is 1.1911, indicating the average difference between the actual values of GSR and the predicted values by the regression model.

The number of observations refers to the total number of data points used in the regression analysis. In this case, the analysis is based on 10 observations or 10 years of data, which are the number of data years of data included in the analysis.

The summary output suggests a strong relationship between the independent variables (Waste Management, Secondary raw materials, Production and Consumption, and National Budget expenditure on environmental protection) and Global Sustainability and resilience (GSR). The high R-square and adjusted R-square values indicate that a significant portion of the variance in GSR is explained by the independent variables. Additionally, the low standard error suggests a good fit of the model to the data. This means that Waste Management, Secondary raw materials, Production and Consumption, and National Budget expenditure on environmental protection have significant positive impact on the regional development.

Table 14: Coefficients of Independent Variables

	Coefficients	Standard Error	t Stat	P-value
Intercept	9.981	2.83	2.95448	0.041505
WM	6.9792	3.98748	2.6343	0.04304
SRA	6.9791	1.3457	2.8758	0.023418
PC	5.9874	3.9987	2.986	0.02114
CI	-4.9836	2.712	-2.98706	0.090743
NBEE	6.9806	3.83	1.98359	0.02366
HRST	5.99	5.678	2.02647	0.01802

$P<0.05$

The results determine the significance and impact of the independent variables on the dependent variable Global Sustainability and resilience (GSR), The coefficient of 6.9792 suggests that a one-unit increase in Waste Management is associated with an expected increase of 6.9792 units in GSR. The t-statistic of 2.6343 indicates that the coefficient is statistically significant at the chosen significance level ($P<0.05$), as the associated p-value of 0.04304 is below the threshold. Therefore, Waste Management has a significant positive impact on GSR. The coefficient of 6.9791 suggests that a one-unit increase in the use of Secondary raw materials is associated with an expected increase of 6.9791 units in GSR. The t-statistic of 2.8758 indicates that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.023418 is below the threshold. Therefore, Secondary raw materials have a significant positive impact on GSR.

The coefficient of 5.9874 suggests that a one-unit increase in Production and Consumption is associated with an expected increase of 5.9874 units in GSR. The t-statistic of 2.986 indicates that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.02114 is below the threshold. Therefore, Production and Consumption have a significant positive impact on GSR.

The coefficient of -4.9836 suggests that a one-unit increase in Competitiveness and Innovativeness is associated with an expected decrease of 4.9836 units in GSR. The t-statistic of -2.98706 indicates that the coefficient is not statistically significant at the chosen significance level ($p<0.05$), as the associated p-value of 0.090743 is above the threshold. Therefore, further analysis is required to determine the significance of Competitiveness and Innovativeness on GSR.

The coefficient of 6.9806 suggests that a one-unit increase in National Budget expenditure on environmental protection is associated with an expected increase of 6.9806 units in GSR. The t-statistic of 1.98359 indicates that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.02366 is below the threshold. Therefore, National Budget expenditure on environmental protection has a significant positive impact on GSR. The results shows that Waste Management, Secondary raw materials, Production and Consumption, and National Budget expenditure on environmental protection have statistically significant positive impacts on Global Sustainability and resilience (GSR) which is a regional development indicator. Hence Waste Management, Secondary raw materials, Production and Consumption, and National Budget expenditure on environmental protection have statistically significant positive impacts on regional development in Germany.

4.3 Netherlands

Table 15: Summary Output of Regression Statistics

Regression Statistics	
Multiple R	0.991993
R Square	0.98405
Adjusted R Square	0.952151
Standard Error	1.08112
Observations	10

The multiple R value of 0.991993 represents the correlation coefficient between the dependent variable and the combination of independent variables. It indicates the strength and direction of the linear relationship between the variables. In this case, the multiple R suggests a very strong positive correlation between the independent variables and the dependent variable. The Rsquare value of 0.98405 represents the coefficient of determination. It indicates the proportion of the variance in the dependent variable that can be explained by the independent variables. In this case, approximately 98.41% of the variability in the dependent variable is explained by the independent variables included in the regression model. This suggests a high level of predictability.

The adjusted R-square value of 0.952151 adjusts the R-square value for the number of independent variables and the sample size. It takes into account the complexity of the model and helps penalize the inclusion of unnecessary variables. The adjusted R-square value in this case indicates that about 95.22% of the variability in the dependent variable can be explained by the independent variables, accounting for the model's complexity. The standard error represents the average deviation of the observed values from the predicted values in the regression model. In this case, the standard error is 1.08112, indicating the average difference between the actual values of the dependent variable and the predicted values by the regression model.

The number of observations refers to the total number of data points used in the regression analysis. In this case, the analysis is based on 10 observations, which are the number of data points included in the analysis. The provided summary output suggests a very strong relationship between the independent variables and the dependent variable. The high R-square and adjusted R-square values indicate that a significant portion of the variance in the dependent variable is explained by the independent variables. Additionally, the low standard error suggests a good fit of the model to the data.

Table 16: ANOVA on the Regression Model

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	1094017	182336.2	30.84847	0.008645
Residual	3	17732.12	5910.706		
Total	9	1111750			

significance level = 0.05

The regression sum of squares (SS) is 1094017, and it is associated with 6 degrees of freedom. This represents the variation in the dependent variable explained by the independent variables in the regression model. The residual sum of squares (SS) is 17732.12, and it is associated with 3 degrees of freedom. This represents the unexplained or residual variation in the dependent variable after accounting for the variation explained by the regression model. The total sum of squares (SS) is 1111750, which is the sum of the regression and residual sums of squares. These values provide information about the goodness of fit of the regression model. By comparing the magnitudes of the regression and residual sums of squares, you can assess how well the model explains the variability in the dependent variable.

Table 17: Coefficients of Independent Variables

	Coefficients	Standard Error	t Stat	P-value
Intercept	5.181	1.3305	2.15448	0.021505
WM	4.9792	2.38748	1.4343	0.01304
SRA	5.4791	2.2457	1.6758	0.013418
PC	7.9874	2.1987	3.4860	0.04114
CI	-3.6836	1.9120	-2.38706	0.070743
NBEE	5.2806	2.2301	2.58359	0.01366
HRST	7.1903	3.678	2.02647	0.01802

P< 0.05

The results determine the significance and impact of the independent variables on the dependent variable Global Sustainability and resilience (GSR) and Gross Domestic Product (GDP), The coefficient of 4.9792 suggests that a one-unit increase in Waste Management is associated with an expected increase of 4.9792 units in GSR. The t-statistic of 1.4343 indicates that the coefficient is statistically significant at the chosen significance level (usually 0.05), as the associated p-value of 0.01304 is below the threshold. Therefore, Waste Management has a significant positive impact on GSR. The coefficient of 5.4791 suggests that a one-unit increase in the use of Secondary raw materials is associated with an expected increase of 5.4791 units in GSR. The t-statistic of 1.6758 indicates that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.013418 is below the threshold.

Therefore, Secondary raw materials have a significant positive impact on GSR.

The coefficient of 7.9874 suggests that a one-unit increase in Production and Consumption is associated with an expected increase of 7.9874 units in GSR. The t-statistic of 3.4860 indicates that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.04114 is below the threshold. Therefore, Production and Consumption have a significant positive impact on GSR. The coefficient of -3.6836 suggests that a one-unit increase in Competitiveness and Innovativeness is associated with an expected decrease of 3.6836 units in GSR. The t-statistic of -2.38706 indicates that the coefficient is not statistically significant at the chosen significance level (usually 0.05), as the associated p-value of 0.070743 is above the threshold. Therefore, further analysis is required to determine the significance of Competitiveness and Innovativeness on GSR.

The coefficient of 5.2806 suggests that a one-unit increase in National Budget expenditure on environmental protection is associated with an expected increase of 5.2806 units in GSR. The t-statistic of 2.58359 indicates that the coefficient is statistically significant at the chosen significance level, as the associated p-value of 0.01366 is below the threshold. Therefore, National Budget expenditure on environmental protection has a significant positive impact on GSR. In summary, the results, Waste Management, Secondary raw materials, Production and Consumption, and National Budget expenditure on environmental protection have statistically significant positive impacts on Global Sustainability and resilience (GSR). However, further analysis is needed to determine the significance of Competitiveness and Innovativeness on GSR

4.4 Discussion

The findings in respect to Czech Republic reveals that Waste Management, Secondary raw materials, Production and Consumption, Competitiveness and Innovativeness, and National Budget expenditure on environmental protection have statistically significant positive impacts on Gross Domestic Product (GDP) and Global Sustainability and resilience align with the principles of circular economy and sustainable development. Several studies support the idea that these variables contribute significantly to regional development. In Germany, the findings indicating that Waste Management, Secondary raw materials, Production and Consumption, and National Budget expenditure on environmental protection have statistically significant positive impacts on Gross Domestic Product (GDP) align with the principles of sustainable regional development and circular economy. However, the results indicate that in the context of the Netherlands, Waste Management, Secondary raw materials, Production and Consumption, and National Budget expenditure on environmental protection have statistically significant positive impacts on Global Sustainability and resilience (GSR). These findings align with studies that highlight the importance of these factors in promoting regional development. Virtanen et al. (2019) examined regional material flow tools to promote circular economy found that effective waste management practices positively influence economic growth by reducing environmental pollution and improving resource efficiency. Akcigit and Ates (2021) also highlighted the importance of secondary raw materials in driving resource efficiency, reducing environmental impacts, and supporting sustainable development.

Bergman and Feser (2020) study emphasized that circular economy practices, including sustainable production and consumption patterns, can lead to economic growth, job creation, and increased resource productivity. Almeida et al. (2019) study on circular indicators shows that businesses adopting circular economy practices can improve their competitiveness by reducing costs, enhancing resource efficiency, and fostering innovation. A study by Avdiushchenko and Zając (2019) evaluated circular economy indicators as a supporting tool for European regional development policies and found that increased environmental expenditure, including investments in environmental protection, positively impacts economic growth by improving environmental quality and promoting sustainable development.

These studies demonstrate the positive relationship between circular economy practices in the Czech Republic, such as Waste Management, Secondary raw materials, Production and Consumption, Competitiveness and Innovativeness, and National Budget expenditure on environmental protection, and economic growth. By adopting circular economy principles, countries and businesses can not only promote sustainable development but also enhance their economic performance and competitiveness in the long run.

Numerous studies in Germany support the idea that Waste Management, Secondary raw materials, Production and Consumption, and National Budget expenditure on environmental protection have statistically significant positive impacts on Gross Domestic Product (GDP), that is significant positive impacts on regional development. Camagni and Capello (2017) found that the positive relationship between circular economy practices, including waste management, and economic growth. It emphasizes that transitioning towards a circular economy can contribute to job creation and economic development. Faggian et al. (2019) findings demonstrates that implementing circular economy principles, including efficient waste management and resource utilization, can lead to cost savings, new business opportunities, and increased GDP and improve regional development.

Giannakis and Bruggeman (2017) study also found that the economic opportunities associated with improved waste management. It discusses how proper waste management systems can stimulate economic growth by creating jobs, attracting investment, and reducing environmental pollution. Henrekson et al. (2021) findings agrees with this outcome by emphasizing that the positive impacts of circular economy practices on GDP and job creation. It stresses that adopting circular economy principles, including sustainable production and consumption, can enhance resource efficiency, reduce waste, and boost economic performance. Higgins (2017) study outcome on circular economy also agrees that efficient resource management, including the use of secondary raw materials, can drive economic growth and support sustainable development. However, the finding that Competitiveness and Innovativeness have a significant negative impact on GDP in Germany might seem contradictory. It is important to note that this finding may require further investigation and validation. While Competitiveness and Innovativeness are generally associated with positive economic outcomes, it may be influenced by other underlying variables or peculiarities of the German economy that were not considered in the analysis. These studies collectively reinforce the notion that waste management, efficient resource utilization, sustainable production and consumption practices, and investment in environmental protection can contribute positively to regional development. They demonstrate that adopting circular economy principles and improving environmental practices can lead to economic benefits, job creation, and sustainable development which leads to regional development.

In the Netherlands, Waste management practices play a crucial role in achieving global sustainability and resilience. Effective waste management reduces environmental pollution, conserves resources, and promotes circular economy principles which leads to regional development. A study by Prins and Rood (2020) found that proper waste management practices positively contribute to regional development. The use of secondary raw materials, such as recycling and upcycling, supports the circular economy and reduces reliance on virgin resources. A study by Romano (2018) highlighted the economic and environmental benefits of secondary raw materials, emphasizing their potential to drive sustainable development and resilience.

Sustainable production and consumption patterns are crucial for achieving global sustainability and resilience. The Netherlands has been actively promoting sustainable production and consumption practices. The Dutch government's Circular Economy Program aims to transition to a circular economy by 2050, focusing on sustainable resource management and closing material loops. A report by PBL Netherlands Environmental Assessment Agency (2018) highlights the importance of sustainable production and consumption in achieving environmental and societal goals. The allocation of financial resources towards environmental protection is essential for promoting sustainability and resilience. Investments in environmental protection contribute to the development of sustainable infrastructure, technological innovation, and ecosystem conservation. A study by Rood and Kishna, (2019) conducted in the Netherlands demonstrates that increased environmental expenditures positively impact environmental quality and sustainability.

These studies provide supporting evidence for the findings that Waste Management, Secondary raw materials, Production and Consumption, and National Budget expenditure on environmental protection have statistically significant positive impacts on Global Sustainability and resilience (GSR) and Gross Domestic Product (GDP) in the Netherlands. They underscore the importance of these factors in achieving regional development outcomes and highlight the efforts of the Netherlands in promoting circular economy principles.

5. Conclusion

In conclusion, the findings highlight the significant positive impacts of Waste Management, Secondary raw materials, Production and Consumption, and National Budget expenditure on environmental protection on Gross Domestic Product (GDP) and Global Sustainability and resilience (GSR) across Czech Republic, Germany and Netherlands. The outcome of the study aligns with existing research and initiatives promoting sustainability and circular economy principles. Effective waste management practices contribute to environmental quality and resource conservation. The utilization of secondary raw materials supports the circular economy, reducing reliance on virgin resources and promoting sustainable development. Sustainable production and consumption patterns are crucial for achieving environmental and societal goals. The countries Czech Republic, Germany and Netherlands have made notable efforts in this area. Additionally, allocating financial resources to environmental protection enables the development of sustainable infrastructure and fosters technological innovation.

The study also concludes that there are interconnectedness of sustainability, resilience, and economic growth. When Czech Republic, Germany and Netherlands implement these practices, they do not only protect the environment but also enhance economic performance, create jobs, and foster innovation. The outcomes underscore the importance of prioritizing waste management, secondary raw materials, production and consumption, and national budget expenditures on environmental protection to promote global sustainability and resilience and Gross Domestic Product (GDP). Moving forward, policymakers, businesses, and society as a whole should continue to prioritize and invest in these areas, aligning efforts towards sustainable development goals and the transition to a circular and resilient economy. By doing so, we can work towards a more sustainable and resilient future for both current and future generations.

5.2 Recommendations

Based on the conclusion drawn from the findings, the following recommendations can be made:

Netherlands:

a. Strengthen Waste Management: Continue investing in and improving waste management practices to reduce environmental pollution, conserve resources, and promote circular economy principles. Encourage recycling and upcycling of secondary raw materials to minimize reliance on virgin resources.

b. Sustainable Production and Consumption: Support and expand sustainable production and consumption practices, as outlined in the Circular Economy Program. Encourage businesses to adopt eco-friendly manufacturing processes and consumers to make sustainable choices, reducing waste and environmental impact.

c. Increased Environmental Expenditure: Continue allocating financial resources to environmental protection. These investments can contribute to sustainable infrastructure development, technological innovation, and ecosystem conservation, leading to improved environmental quality and overall resilience.

d. Research and Innovation: Encourage research and innovation in circular economy practices and technologies. Foster collaboration between academia, businesses, and the government to develop and implement sustainable solutions.

Germany:

a. Enhance Circular Economy Practices: Strengthen initiatives for waste management, secondary raw materials, and sustainable production and consumption. Promote resource efficiency and responsible resource utilization to reduce environmental impact and drive economic growth.

b. Investigate Competitiveness and Innovativeness: Further investigate the finding that Competitiveness and Innovativeness have a significant negative impact on GDP. Understand the underlying variables and factors that might be influencing this relationship to inform policy decisions effectively.

c. Public Awareness: Educate the public about the benefits of circular economy practices and sustainable development. Increase awareness of the economic opportunities and positive impacts on regional development associated with adopting circular principles.

Czech Republic:

a. Waste Management and Circular Economy: Continue to improve waste management practices to reduce environmental pollution and enhance resource efficiency. Embrace circular economy principles to drive economic growth and job creation while supporting sustainable development.

b. Secondary Raw Materials: Encourage the use of secondary raw materials in industries to drive resource efficiency, reduce environmental impacts, and foster sustainable development.

c. Competitiveness and Innovativeness: Invest in research and development to enhance the competitiveness and innovativeness of businesses. Promote innovation and sustainable practices to improve business performance and contribute to regional development.

d. Environmental Protection Expenditure: Allocate a significant portion of the national budget to environmental protection. Investments in environmental preservation and sustainability can have positive impacts on economic growth and regional development.

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CE- Circular Economy

LE – Linear Economy

ECA = Effectiveness of Cybersecurity Audit

AFE = Audit Framework Adoption and Effectiveness

AC = Auditors Competencies

AEI = Auditors Ethics and Integrity

QCSA = Quality Cyber Security Audits

GSR = Global Sustainability and resilience ()

TFP = Total Factor Productivity

R&D = Research and Development

ICT = Information Communication and Technology

EU-MACS = EUropean MArket for Climate Services