Czech University of Life Sciences Prague

Faculty of Economics and Management

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Master's Thesis

Zero waste and the circular economy: case study of Sweden

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

DIPLOMA THESIS ASSIGNMENT

Bc. Aigerim Zhaxylyk

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Thesis title

Zero waste and the circular economy: case study of Sweden

Objectives of thesis

In recent decades numerous debates have been taken place around sustainable development and the necessity to support environmentally friendly ways of production. In this light, it becomes interesting to investigate what actions have been done in this regard in the sphere of a circular economy. The analysis of interconnection between stated goals and achieved results in the selected country becomes the main aim of this Diploma Thesis.

Methodology

Theoretical part of the Diploma thesis will be mainly based on a relevant literature review and the research of similar studies, using methods such as abstraction, inductive reasoning, analysis, synthesis and deduction.

Practical part will rest on descriptive statistical analysis and qualitative thematic synthesis of the selected indicators and variables. The results of the conducted analysis along with the author's recommendations will be provided and discussed in the Diploma's conclusion.

The proposed extent of the thesis

60-80 pages

Keywords

Circular economy; Zero waste; Sustainable development

Recommended information sources

ANDERSON, T W. *An introduction to multivariate statistical analysis.* Hoboken, N.J.: Wiley-Interscience, 2003. ISBN 0471360910.

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Sillanpää, M., & Ncibi, C. (2019). The Circular Economy: Case Studies about the Transition from the Linear Economy. Academic Press.

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Declaration

I declare that I have worked on my diploma thesis titled "Zero waste and the circular economy: case study of Sweden" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the diploma thesis, I declare that the thesis does not break copyrights of any their person.

In Prague on 31.03.2022 ______________________________

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Zero waste and the circular economy: case study of Sweden

Abstract

Sweden, as many other countries all over the world, sees the circular economy as a method of meeting emissions goals, improving standard of living, and increasing economic competitiveness. However, although the why of the circular economy is evident, the how is a significant difficulty. The movement to a circular economy is dependent on mechanisms that promote waste treatment and resource cycling. These systems are built on enabling technology.

The study subject examines the adoption of the circular economy idea in Sweden from 2000 to 2019 and how it has affected economic development. The most frequent linear economic model is predicated on the belief that resources are infinite and that waste disposal space is infinite. A paradigm like this is plainly unsustainable, and adjustments must be done. The notion of the circular economy is still poorly understood by me. Transitioning to a circular economy demands structural changes in industry, social components, energy, transportation, agriculture, and other areas.

Keywords: Circular economy; Zero waste; Sustainable development; Sweden, Recycling; Economic growth.

Nulový odpad a oběhové hospodářství: případová studie Švédska

Abstrakt

Švédsko, stejně jako mnoho dalších zemí po celém světě, vnímá oběhové hospodářství jako způsob plnění emisních cílů, zlepšování životní úrovně a zvyšování hospodářské konkurenceschopnosti. Ačkoli je však zřejmé proč oběhového hospodářství, jak je významný problém. Přechod k oběhovému hospodářství je závislý na mechanismech, které podporují nakládání s odpady a cyklování zdrojů. Tyto systémy jsou postaveny na technologii umožňující.

Předmět studie zkoumá přijetí myšlenky cirkulární ekonomiky ve Švédsku v letech 2000 až 2019 a jak ovlivnila hospodářský rozvoj. Nejčastější lineární ekonomický model je založen na přesvědčení, že zdroje jsou nekonečné a že prostor pro likvidaci odpadu je nekonečný. Takové paradigma je zjevně neudržitelné a je třeba provést úpravy. Pojem cirkulární ekonomika je mi stále špatně pochopen. Přechod na oběhové hospodářství vyžaduje strukturální změny v průmyslu, sociálních složkách, energetice, dopravě, zemědělství a dalších oblastech.

Klíčová slova: Oběhové hospodářství; nulový odpad; Udržitelný rozvoj; Švédsko, Recyklace; Hospodářský růst.

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List of abbreviations

BLUE - Best Linear Unbiased Estimate

CE – Circular Economy

C2C – Cradle to cradle

EASAC - European Academies' Science Advisory Council

EEC – European Economic Community

EU – European Union

GDP – Gross Domestic Product

GO – Government Organization

LCA – Life -Cycle Assessment

MSP – Municipal Solid Pollution

MSW - Municipal Solid Waste

OLS - Ordinary least squares

PRO- Producer Responsibility Organization

PWGSC – Public Service and Public Works Canada

SEK- Swedish korona

UN – United Nation

USA – United States of America

WFD - Waste Framework Directive

ZWIA - Zero Waste International Alliance

1 Introduction

Circular economies, and hence more sustainable economies, are extensively pushed in policy, business, and academics across the world. While CE encompasses a wide range of concepts, tools, and tactics, practically all approaches use a "R-framework." A series of economic actions meant to close and slow material cycles, such as reuse, repair, and recycling, are often placed in a priority or hierarchy order. These frameworks are frequently referred to as xR. (where x is the currentnumber of strategies that an actor promotes in their definition of CE). For example, the 9R framework addresses discard, rethink,reduce, reuse reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, and recover. Despite the consistent inclusion of repair in such frameworks, policy, industry, and academia rarely focus on either the opportunities or the challenges involved in repair as part of an economic or cultural strategy to achieve circularity, and so far, despite CE emerging as a central topic at the highest political and economic level, and recent measures regarding "Rights to Repair," no government has set policy targets for repair. In condition that CE is to change the way natural systems and commercial activity interact, its political implications must be better understood.

My choice of Sweden for this study is partially for practical reasons, but it also reflects the country's self-proclaimed CE leadership and fiscal incentives for repair, which half the rate of value-added-tax on repair and allow tax credits for house maintenance and repair. These measures show Sweden's long-standing aspirations to support both ecological citizenship, an approach to promoting pro-environmental behaviour based on changing attitudes through education to spread cosmopolitan values and associated social responsibilities, and ecological modernisation, the greening of the industrial economy through consumer choice, as part of a distinctively Swedish "economic model" in which a tripartite state-business-labour consensus supports a significant increase in productivity. Despite increased market liberalization, the effects of the financial crisis, and emerging social fragmentation common to European countries, as illustrated here by the rise of the far-right Sweden Democrats as a significant political force, this consensus has been largely maintained to the present day.

By focusing on repair in Sweden, this paper provides analysis and critique of specific material circular economy approaches as implemented in a specific geographical and politico-economic context, as well as an examination of future development expectations rooted in an actual existing political economy. In the practical section, examine the relationship between recycled trash, GDP, governance export and import, and the extent to which the political economy is perpetuated or modified.

2 Objectives and Methodology

2.1 Objectives

Recent decades numerous debates have being taken place around sustainable development and the necessity to support environmentally friendly ways of production. In this light it becomes interesting to investigate what actions have been done in this regard in the sphere of circular economy. The main goal of the thesis is to analyze the relation between GDP growth and circular in selected country. In addition to examine the strategy of transition to circle economy in Sweden.

2.2 Methodology

Theoretical part of the Diploma thesis will be mainly based on a relevant literature review and the research of similar studies, using methods such as abstraction, inductive reasoning, analysis, synthesis, and deduction.

In practical part will be obtained the GDP growth, export and import of goods and service and municipal recycling waste from 2000-2019 years. For the analyse will be used econometrical analysis, regression model, statistical method presenting in tables, furthermore autocorrelation test, Heteroskedasticity test and normality test.

3 Literature Review

3.1 Definition of Zero Waste

ZWIA,2014 stated that Zero Waste is a goal that is ethical, economical, efficient and visionary, to guide people in changing their lifestyles and practices to emulate sustainable natural cycles, where all discarded materials are designed to become resources for others to use. Zero Waste means designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them. Implementing Zero Waste will eliminate all discharges to land, water or air that are a threat to planetary, human, animal or plant health.

Zero waste is a lifestyle and an aim. Only by closing the circle, we can expect to evolve a sustainable economy. The concept is to decrease the consumption of goods and their packaging that are harmful to the environment and to make all products and packaging recyclable. Attaining Zero Waste depends on designing outputs and industrial processes thus that their components can be disassembled, renovated, and recycled. Zero Waste means associating communities, businesses, and industries thus that one`s waste becomes another's raw material. It means preventing contamination at its source.

A better quality of life for future generations is the main goal of the sustainable development strategy. Environmental protection, sustainable economic growth and employment, and social progress that meets everyone's needs are key elements of such a strategy. But until people fully learn to implement the fourth component – the prudent use of the Earth's natural resources – it is highly doubtful that the first three can be achieved.

Energy and resource conservation and waste reduction are one of the main components of sustainable development. "In order to achieve true sustainability, we must reduce our 'junk index' – something that we constantly throw out into the environment and that cannot naturally be recycled for recycling-to net zero."» (Murray, 2002)

The Earth's biosphere is dominated by closed cycles. Waste does not accumulate and does not become a problem of the economy of nature. Instead, they decompose and become part of the raw material for new growth. To achieve sustainability, people must learn to "act from nature". Nature has developed the longest-functioning, most successful of all models – the zero-waste model (Murray, 2002).

Human is the only species on the planet that does not live according to the principle of zero waste. The "take, make, and throw away" mentality that has guided our economy for decades must be replaced by the desirable and fantastic goal of zero waste. The economy of humanity is indisputably dependent on the economy of nature. Society cannot explicitly allow itself to continue to deplete the resources of nature, many of which (especially metals, petroleum products and other minerals) are available in limited quantities in the environment or are difficult or environmentally dangerous to extract (Murray, 2002).

Recycling has been ranked as the most successful environmental initiative in human history. However, despite the progress in this direction, we are producing more and more waste.

Clean production, or 3R2 (reducing the amount of waste at the production level, recycling, recycling), environmental efficiency, 50 % reduction of waste in landfills – these are all the first big steps. But it's not just waste management that we need to get rid of. We need to achieve the goal of a zero-waste society (Murray, 2002).

It's time for a radical new approach. Having adopted "zero waste" as the goal, the first thing we should do is to abandon the idea of waste. Everything is made of resources, and waste is a resource moving in the wrong direction. "Throwing away" resources is inefficient and uncompetitive. By changing the way resources flow throughout society and in all localities, we can achieve significant environmental, economic, and social benefits.

Much of the goal of reducing waste by 50 % has been achieved by switching to lightweight packaging instead of new innovative packaging methods made from recyclable plastics. From 1990 to 1997, the use of plastic packaging increased fivefold by weight compared to plastic recycled through recycling. A third of our waste is still packaging, which is used a few seconds after sale and then discarded (Murray, 2002).

Zero waste is a new planning approach for the twenty-first century that implements the principles of resource conservation, minimizing pollution, creating maximum employment opportunities, and providing the greatest degree of economic self-confidence.

It's time to look at the twenty-first century as an era of materials management, not solid waste management.

Zero waste is an integral part of the new economy, which has many components. Waste reduction, redesign, reuse, refilling, regeneration, recycling, repair, remediation, restoration, reconstruction, recharge, recycling, resale, dismantling, and composting are some of the components of the zero-waste program. And all these components provide effective employment and opportunities for economic development (Jessen, 2000).

The emphasis in this direction is on the process of returning the used, worn-out product as close as possible to the new production. The product is completely disassembled, cleaned, inspected, recycled, reassembled, and inspected to ensure functional quality. Recycling is an environmentally and economically desirable form of recycling.

Thus, the Zero Waste program aims to:

- find cost savings and new revenue in existing processes;
- creating new markets for existing products and services;
- development of new technologies, processes and products;
- identification of new organizational, legal and economic innovations;
- the development of infrastructures that contribute to the sharing, reuse and recycling;
- addressing the cumulative effects of production and consumption.

3.1.1 Approaches to live a waste-free life

Achieving non-waste is not as difficult as it may seem at first glance. The basic principle is to replace everything that is disposable with a reusable one, or to completely abandon some things that are not particularly necessary. A complete list of what you should give up and what you can replace it with to reduce your eco-footprint.

1.Say "No" to buying new clothes

Every year, billions of kilograms of clothing around the world end up in landfill. This is greatly facilitated by fast fashion and trends that are promoted to us from all social networks and which turn out to be anti-trends even before the end of the season. Trendy things are specially made of poor quality to make you run to the store for a new T-shirt as soon as the previous one is covered with pellets, without surviving the first wash. This is a negative and wasteful cycle, so find the strength not to be a part of it.

Look in your closet, donate or sell the clothes that you no longer wear, and create new bows with the things that are left. If you still need things to create a basic wardrobe, give preference to buying high-quality things that will last you a long time, as well as things from your hands-on Internet sites, in a thrift store or second-hand (Jonson,2013).

2. Refuse plastic bottles and disposable coffee cups

On average, one person uses about 100 plastic bottles and 500 disposable cups a year, and this is just a huge amount of unnecessary garbage. You can easily change this – just buy yourself a reusable water bottle and a thermos cup for hot drinks. In addition, if you take water or coffee with you from home, you will also save a significant amount of money. On coffee alone, you can save from $500 to $1000 annually, depending on the price of coffee (for example, the price of $1-2 per cup was taken) (Jonson,2013).

3. Stop using disposable plastic drinking straws

Straws or straws for drinks can certainly not be called a necessity. They will be useful to us for 10 minutes, after which they will go straight to the landfill as garbage that is not recyclable. Therefore, if you want to get closer to a waste-free lifestyle, give them up completely or buy a reusable analog made of bamboo, stainless steel, or silicone (Jonson,2013).

4. Try to eat less fast food and order delivery

Very often, various plastic containers, disposable appliances and a large number of bags are used for packaging and delivery of takeaway food. You can reduce the amount of garbage you produce by starting to cook more at home or choosing a delivery that uses eco-packaging. In the case of takeaway food, do not hesitate to bring your own container and ask to pack your food in it. (Button,2018).

5. Do not use disposable dishes

Just give it up. It is not always recycled and looks completely unsightly. If you are going on a picnic, prepare a set of reusable dishes in advance, such as plates and bowls made of metal and ordinary cutlery (Button,2018).

6. Give up washing up sponges

A sponge is a useless thing that absorbs germs and is not recyclable. An alternative is a wooden brush for washing dishes (Rhoads, 2018).

7. Learn how to buy products without bags

Buying products without packaging is easier than it seems at first glance. It's all a matter of habit. When you decide to go shopping, take reusable bags and bags with you, so as not to take cellophane ones in the store. Today you can buy not only large fabric bags, but also small ones for vegetables and fruits. Remember that some fruits can do without a package at all, for example, lemon, grapefruit, and bananas (Carter, 2019).

For cereals and pasta, prepare reusable cans in advance. And if you still need to buy something in a package, try to choose a package made of glass or metal, which is 100% recyclable (Carter, 2019).

Zero Waste purchases may require additional travel, because buying farm fruits and packing them in your own packaging is much more pleasant than taking plastic apples pre-packaged in plastic from the supermarket. The first option is better, because this way you support local entrepreneurs, take care of the environment, and consume a delicious and high-quality product. (Carter, 2019)

Never use plastic bags again!

Using only reusable bags, you make an invaluable contribution to our ecology. Now there are a variety of bags with different designs, made of cotton or burlap. Keep them in the hallway, in the car, at work, and in your purse-just eliminate situations where you may find yourself without an eco-bag (Rhoads,2018).

3.1.2 The Global Zero Waste Initiative

In 1996, **Canberra** became the world's first city to pass Zero Waste legislation. The city of Canberra achieved 70 percent trash diversification in 2004. One of Canberra's projects is to construct a "Resource Recovery Park" to assist business in creating goods from separate materials and marketing reusable resources (Access Canberra,2021).

Adelaide, a South Australian city, has designed and executed a Zero Zaste plan. The trash composting program is expanding considerably, and by 2015, the compost volume must be greater than the garbage delivered to landfills. The city has a high rate of waste diversification, with a rate of 82 percent (Access Canberra. 2021).

Stockholm is one of Europe's top cities, with strong environmental standards and aspirations to enhance environmental quality. Stockholm has already made strides toward its aim of being a fossil-free city by 2050 (Stockholm zero waste, 2019). One of the primaries aims of this 2030 vision is to make Stockholm a more resource-efficient city (RUFS, 2010).

New Zealand has been on this path since March 2002. Almost 50 % of all territorial local authorities have now committed to an ambitious plan to make New Zealand a world leader in reducing waste (Zero waste network, 2002)

Public Service and Public Works **Canada** (PWGSC) is phasing out a zero waste Program across all federal agencies and encouraging federal departments and agencies to reduce the amount of non-hazardous solid waste sent to landfill and thereby reduce the amount of greenhouse gas emissions from solid waste. To assist in the development and/or improvement of solid waste management programs, information is provided, and experience is shared in the areas of solid waste reduction, reusing and recycling (Government of Canada, 2021)

San Francisco, with a population of 850.000, has achieved the highest percentage of waste diversification in the United States through a three-pronged approach: enforcing strict waste reduction laws, partnering with waste management companies to develop innovative programs, and working to create a culture of recycling and composting through incentives and community outreach. San Francisco seeks to reach the Zero Waste objective by 2020 (Zaman AU and Lehman S, 2013).

Bitetto, a tiny municipality on Italy's south-east coast near Bari, raised its share of total municipal solid trash created in 2020 from 16.67 percent in 2016 to 78.32 percent in 2020. Furthermore, the municipality generated just 79.29 kg of non-recyclable (residual) garbage per person in 2019 (McQuibban, 2021).

The city of **Burbank**, located in the state of California, currently has a population of about 100 thousand people and 5,000 businesses. The "Zero Waste Race Program" has been at the heart of the Recycling Center's driving forces since 1997.Several specialists have been exploring all sorts of ways to reduce waste. Their ideas included expanding the different recyclable materials that are collected and trying to get more people interested in recycling and composting by educating them. The emphasis was on teaching school-age children in the hope that children would teach adults (City of Burbank, 2019) The city's schools have recycling bins, and several schools recycle half of their waste. The city's Recycling Center also offers guided tours to the Training Center to teach school-age children and adults about vermicomposting (about 1,500 children take part in these tours throughout the year). The city of Burbank received the "Helen Putnam Award of the California League of Cities for Excellence" in the Land Use and Environmental Quality category for its Zero Waste program in 2000 (City of Burbank, 2019).

More and more businesses across **Japan** have made commitments that they should not allow waste to be disposed of in single-use containers or non -recyclable waste outside of businesses. All four major Japanese breweries (Kirin, Asahi, Suntory, Sapporo) have committed to achieving the zero emissions target by 2010.

European countries are also assessing in detail the economic benefits of recycling and recycling. Recent German studies estimate that the country's waste and recycling industry has more than 1,000 firms, which on average employ 150 people each (of which 17,000 jobs are in packaging recycling alone) (Murray,1999).

The turnover of the recycled materials market is from 80 to 100 billion euros per year. This is more than employment in the steel or telecommunications industries in Germany (Murray,1999).

In Western Europe, the Netherlands is leading the way in waste management policies that focus on addressing the problem of preventing waste generation at the source, i.e. at the very beginning. Only 4 % of the waste generated in 2010 can be deposited in landfills. In 2000, about 6 million tons of waste were deposited in landfills (Kroon, 2018).

3.2 The circular economy concepts

Korhonen stated that the concept of circular economy was born in the mainstream of two sciences – ecology and economics, and therefore the first works on the development of this concept were of an ecological nature. Therefore, in 1966, the theory of the American economist K. Boulding was put forward that " The Earth has become the only spacecraft on which there are no unlimited reservoirs, so man must find his place in a cyclical ecological system".

Over time, the concept has become more economic in nature. Since the 1970s, the concept of a circular economy has been actively developed by Walter Stahel, a Swiss architect who first proposed the idea of moving to a "cyclical" (circular) economy. He saw it as a replacement for the existing linear industrial model of constant resource-dependent growth (Varian,1992).

In 1989, the applied science of industrial ecology was born (Whybrow,2015). Another significant step was the unification of views on biomimicry under the authorship of Janine Benius (Frodermann,2018). The milestones described above have a common idea, which is the need to apply the circulation of all-natural resources to achieve a sustainable future on the planet.

A review of the literature has shown that the term "circular" economy has many interpretations in foreign studies (Korhonen et al., 2018, Kirchherr et al., 2017). It is an economy that relies on closed cycles, recycling, extended product life, and treats waste as valuable secondary materials (Jastrzkbska, 2017).

Circular economy – an economic model that encompasses all activities aimed at limiting the reuse and recycling of materials during production, distribution, and consumption (Blomsma & Brennan, 2017). An important link in the system of circular economy is the concept of balanced consumption and production.

One of the most well-known definitions is provided by the Ellen MacArthur Foundation: "The circular economy is restorative and self-contained, seeking to preserve products, components, and materials with maximum utility and value.

The economic benefits and employment opportunities associated with circular economy incentives and business models are often emphasized, and they also act as motivational players for private firms and investors or other stakeholders (Gisellini, 2017; Ellen MacArthur Foundation, 2017). Some studies have shown that successful implementation and evaluation of circular economy initiatives and projects requires an integrated bottom-up approach (support and participation of industries and stakeholders) and a top-down approach (e.g., subsidies or tax incentives) (Winans et al., 2017). In addition, one of the key issues in promoting circular economy business models is raising awareness among both consumers and producers (Ghisellini et al., 2016)

The Circular economy is a concept of creating value through the rational use of resources and minimizing the negative impact of products on the environment at all stages of the product life cycle, which allows the reuse of used materials (Pahomova,2017). In its basic principles, the circular economy concept uses both old and new concepts that contribute to mitigating the negative impact of products on the environment that enterprises produce, and includes the following concepts:

- from cradle to cradle (C2C);
- 3R (reduction, reuse and recycle) and 4R (reduction, reuse, recycle and repair);
- LCA;
- cleaner production;
- industrial ecology;
- sustainable supply chain management;

- green supply chain.

All these concepts fit into the implementation of the idea of sustainable development.

In the current international political discourse, efforts aimed at sustainable development are mainly based on the 2030 Agenda (Korhonen,2018) and the Sustainable Development Goals adopted by the United Nations in 2015 (Smith et al., 2018)

Prieto-Sandoval et al noted the circular economy is based on the ideas of industrial ecology and industrial metabolism, promotes the reduction and efficiency of resource use, the reuse and processing of industrial products, and the extension of product life. Engineering-driven innovation forms the basis for such industrial change, as defined in the comprehensive literature reviews conducted by Kirchherr et al. (2017).

The circular economy offers great opportunities for companies that seek to optimize their business practices while reducing the burden on the environment. As a result, the circular economy is often seen as a steppingstone on the path to sustainability. However, to ensure a sustainable transition from a linear to a circular economy, the transition requires the implementation of not only financially profitable closed strategies, but also environmentally and socially significant ones. The challenge for businesses is to understand how a particular closed initiative in the context of their business contributes to sustainability and what elements of sustainability should be evaluated before implementing the initiative (Grigoryan,2018).

3.2.1 Difference between a linear and circular economy

A linear economy is aimed at constant production and consumption, while the goods produced have a simple path from cradle to grave. That is, resources are taken, used, and sent to the trash without returning to the production cycle, as is the case in a circular economy.

In a linear economy, manufacturers stimulate sales in various ways, for example, they put the so-called planned obsolescence in the product. It assumes that each item has a certain service life, after which it becomes more difficult and more expensive to repair it than to buy a new one. For this reason, the product can be sold cheaply (Skripnyuk, Kikkas, Didenko, 2018).

Figure 1: Differences between circular economy and linear economy

Source: https://www.constructionspecifier.com/the-circular-economy/

Proponents of the circular economy believe that this approach is not rational and leads not only to resource losses, additional spending on waste disposal, but also to a deterioration in the quality of goods and an increase in consumer dissatisfaction. In contrast to the planned obsolescence, there are, for example, "lifetime" guarantees for things, when the manufacturer (seller) is responsible for the broken product, he is ready to take the thing to repair. If a thing has lost its consumer properties, it is the manufacturer who takes care to make a new one out of it, without removing it from the cycle. Therefore, instead of the overproduction race proposed by the linear economy, the circular economy offers a less intensive, but more prudent model of production-consumption (Varkholova, Dubovitska, 2015; Skripnyuk, Kikkas, Didenko, 2018).

Table 1: Comparative characteristics of the linear and closed model

Comparison features	Circular economy	Linear economy
Subject	The consumer acts as an integral part of society and nature.	A consumer who pursues exclusively the maximization of their benefits.

System integrity	Interconnectedness, the trinity of economy, ecology and society.	The market acts as a complete system.
The main purpose	Achieving ecological balance with sustainable economic and social growth of the well-being of the world's population while maximizing the efficiency of the life cycle of various resources, goods and services	Obtaining the maximum possible economic profit, while environmental issues are not given due attention. The well-being of the world's population is growing extremely unevenly, there is a powerful social stratification.
Production volume	A closed production cycle is aimed at minimizing the quantity of goods produced, usually of higher quality and subject to repeated use.	Continuous increase in the number of goods and services produced (often of poor quality), increasing the rate of production in all industries. There is a crisis of overproduction and excess of the commodity market.
Consumption volume	Building a new model of consumption of goods and services, from the point of view of their necessity and importance for the consumer.	Satisfaction of excessively excessive desires, characteristic of the behavior of the super-consumer.
Type of nature management	Resource-producing.	Resource-consuming.
The relationship between society and nature	Active implementation of greening in production processes. Reduction of anthropogenic load on ecosystems.	Nature is being actively transformed, and the anthropogenic load on ecosystems is increasing, which creates an ecological crisis of a planetary scale.
Resources used	The interaction of financial, informational, intellectual, labor and other resources used in the process the receipt and use of products from recycling of secondary resources.	Primary resources extracted in nature, usually without taking into account the environmental damage and damage caused by anthropogenic activities.
The amount of waste	Gradual reduction to complete extinction through the application of new approaches available in the process of technological development. The emergence of new industries.	The permanent growth of production and consumption waste, the rapidly accumulating volume of which leads to a global environmental problem.

Predominant type of production	Development and creation of knowledge-intensive, innovative and intellectual types of production.	Labor-intensive production prevails, with a low level of innovation activity and the involvement of various types of IA.
Social partnership	An active social and environmental position of the company with a high initiative responsibility of the business.	An environmentally illiterate society with the majority of environmentally irresponsible enterprises that meet the requirements in the field of ecology, in most cases, under duress.
Product life cycle	Maximization of the duration of the product (service) life cycle, in which it can be processed and reused.	The short life cycle of the product, coupled with its rapid obsolescence.

Source: "Methodological tools for assessing the ecologization of the territory" Gureva, 2013,

According to projections, the development of an economic system based on the circular economy idea can deliver global GDP growth of up to 7% each year. Government agencies and organizations rely heavily on the Foundation's findings and developments (Aleksandrova, 2017).

3.2.2 Stages of formation of the circular economy

The formation of the circular economy took place in three main stages (Table 2):

Table 2:Stages of formation of the circular economy

Time period	Title	Period description
1970-1990	**Waste management**	A number of environmental legislative measures have been adopted in European countries and the United States. In political circles, the concept of 3R (reduce, reuse and recycling) is becoming more and more interesting. The actions taken at the state level are restrictive, considering the preferences of the manufacturer. The principle known as "the polluter pays" is emerging. The issue of waste management is central, but due to the lack of environmental culture and thinking, the approach in which the territories of fewer rich countries were used for waste disposal and/or recycling is gaining popularity. Actively developing television and mass media pay attention to the ongoing environmental changes; scientific literature on waste disposal, collection, and management appears.

1990-2010	**Eco-efficiency strategies**	The idea of environmental payments (pollution charges) had a certain influence on the formation of the circular economy (Brundtland Report, 1987). Environmental problems were perceived by society as an economic opportunity. In the early 2000s, with the spread and development of the Internet and the increased speed of information exchange, a number of environmental problems were recognized as global (destruction of the ozone layer, global warming, etc.), The scientific community is actively developing possible ways of waste-free production, but only in the industrial sphere. In a number of non-scientific literatures, the first mention of the circular economy appears, for example, Scopus in 2004. The idea of saving the "closed cycle" is gradually gaining popularity.
2010-present	**Maximum conservation in an era of resource depletion**	Since about 2010, the concept of circular economy has absorbed the most viable ideas of theoretical research into its final form. The central problem is the constant threat to the survival of humanity due to the reduction and gradual disappearance of the necessary natural resources, the growth of the world's population and the number of wastes. In particular, the ideas and developments in the field of circular economy created by the team are widespread The Ellen MacArthur Foundation. It is planned that further economic growth is independent of natural resources, thereby overcoming the energy dependence of the economy and preserving the ecosystem of a planetary scale. Experts suggest that companies develop taking into account three key principles: green innovation, alternative sources, and changing the industrial paradigm. At the moment, about 500 companies in the world use the circular economy strategy.

Source: compiled by the author based on the source (Reike, Vermeulen, Witjes, 2018)

The analysis of the literature sources has shown that most authors use the basic principles of the circular economy in their descriptions. The particle "re" (from Latin means "again"), which characterizes the basic essence of the circular economy (Reike, Vermeulen, Witjes, 2018).

The circular economy was initially based on three key principles, called "3R": reduce (reduction) - reuse (reusing) – recycle (recycling), which eventually transformed into "9R". It should be noted that their further possible development remains unknown (Table 3).

The lack of a clear conceptualization of the basic principles, coupled with an ever-increasing number of additional emerging directions in the study of R-imperatives, can be explained by the following:

- a large number of authors from various scientific schools are engaged in the study of circular economy, which does not allow us to define a clear field of knowledge;
- circular economy is not a strictly isolated field of study, it is very origin took place at the junction of a number of sciences;
- the globalization processes taking place in the scientific environment allow us to identify and present previously unknown research to the world scientific community, which affects the dynamic perception of the circular economy (Belik, Starodubets, Ivlev, Zverev, 2018).

Table 3:Development of the basic principles of the circular economy

3R General model of the circular economy	**4R Circular economy: priorities and mechanisms**	**5R Principles of circular economy**	**9R Principles of the use of goods and material resources**
Reduce	Design and selection of materials	Reduce	Refuse
Reuse	Cascade interaction	Reuse	Reduce
Recycle	Increase the service life of the product	Recycle	Reuse
	Changing the consumption model	Recovery	Repair
	Resource management	Reclamation	Refurbish
	Infrastructure development		Remanufacture
	Restore resources		Repurpose
	Safe disposal		Recycle
			Recover

- international organizations use different R-principles in their terminology and official documents, sometimes not consistent with each other

(Reike, Vermeulen, Witjes, 2018; Julian Kirchherr, Denise Reike, Marko Hekkert, 2017).

According to the developments of The Ellen MacArthur Foundation (the fund-ambassador for promoting the ideas of the circular economy), there are several features of it:

- maintaining a sustainable balance of natural resources and monitoring their condition and use to avoid depletion of natural capital;

Refuse - avoiding excessive use of raw materials. When considering the consumer, it implies a conscious choice to buy and consume less of them. A number of sources emphasize the rejection of consumption in the direction of reducing waste (for example, the rejection of packaging paper, disposable tableware, etc.). In relation to enterprises, all stages of the product life cycle are affected, including design, production processes, etc.

Rethink - rethinking the product life cycle and the use of raw materials.

Reduce - reducing the use of raw materials, aimed at the total elimination of waste production, both at the level of a particular individual and on a production scale.

Reuse - reuse of a product that has lost its value to one user but is needed by another. Active development of resale processes among consumers, especially with the use of popular Internet sites, online auctions and stores (eBay, Amazon, etc.)

Repair - maintenance and repair of a defective product in order to extend its service life. There are several options for implementing this principle: the implementation of repairs through the company in private, the opening of manufacturers 'own repair shops-centres, etc. for the implementation of planned or" special " repairs.

Refurbish - updating and / or restoring an old product while keeping most of it unchanged, for example, repairing buildings and structures, heavy machinery, etc.

Remanufacturing - the production of new products from elements of the old one or the replacement of most of the multicomponent product to extend its life cycle.

Repurpose - use of the product for other purposes or the more common definition of "second life of discarded things". It is similar in its intended purpose to 1R, but it is more common not in a production environment, but in a design environment.

Recycle - processing and obtaining goods from secondary resources, - sorting waste of various origins to "capture" and return "clean" resources to the production cycle.

Recover - collecting materials and products for processing and / or generating energy from biomass.

- development, distribution and widespread implementation of optimization processes for the production of products to achieve the maximum level of their reuse;
- improving the efficiency of economic and environmental systems of production activities by levelling negative effects.

The practical application of the circular economy can be traced at all levels of economic activity in the world-from the actions of an individual to the planetary level of interaction between representatives of countries, which will allow for the transition from a linear model of the economy (Aleksandrova, 2017).

Kirchherr et al (2018) noted when implementing the concept of circular economy in practice, there are barriers of the following nature:

1. Cultural (environmental culture of companies, lack of interest and awareness of the consumer, work on the principles of linear economics, interest in the final value chain);
2. Normative (boundedness of closed procurement, the absence of a global consensus that the prohibition of laws and regulations);
3. Market-based (low-quality materials, standardization, high investment value, limited financing of circular business models);
4. Technology (the ability to deliver high quality remanufactured products, the lack of scale demonstration of the design decisions, the lack of available data on the impact of).

3.2.3 Challenges in Measuring Efficiency in a Circular Economy

Potting et al. noted that measuring the development of CE may be done through indicators. He categorized indicators into two groups: quantitative and semi-quantitative. The principles of these indicators are as follows: quantitative as a single figure (calculated) and semi-quantitative as "yes" or "no" questions divided into groups. The advancement of CE may be tracked in a semi-quantitative way by categorizing the population as "all, many few, none." This allows us to assess our progress. Although the semi-quantitative measurement approach as stated is considerably superior for evaluating the transition of CE rather than its consequences. In reality, the word "cradle-to-grave" has been referenced in Potting's book. It is also advised that Cradle-to-grave energy consumption be assessed for specific items as well as the entire comparable industry. The cradle-to-grave system is a method in which hazardous materials and their treatment, transportation, and disposal are supported by the necessary documentation. Furthermore, as indicated in the paper, the energy consumption of the recycling process should be measured for each individual product unit as well as for the sector as a whole. The goal of these computations is to achieve the highest level of efficiency in CE (Potting, 2017).

According to the European Advisory Council for the Academic Sciences, researchers find it challenging to construct indicators that assess levels of CE performance in businesses, i.e., to identify indicators that quantify waste reduction, reuse, and recycling. Therefore, it is critical to educate entrepreneurs and researchers on how to measure the influence of CE on organizational efficiency levels (EASAC,2016).

According to Bocken et al., on many occasions, companies are unable to propose solutions to problems derived from CE due to a lack of indicators and targets, i.e., a lack of knowledge about the alternatives produced by CE and its economic benefits to the business world and society in general, as it is a new scientific field of study (Bocken, N.M, 2017). Haas et al. discuss the need of developing a set of trustworthy indicators as instruments for measuring and quantifying the benefits of CE (Haas, 2015). This statement is supported by the European Commission, which has also recognized the need for circularity indicators in its action plan for the European Union, stating that "it is important to have a set of reliable indicators to assess progress towards a more circular economy and the effectiveness of action at the national and EU level." (European Comission,2015).

As a result, this section demonstrates what dimensions a manager should consider when defining a CE indicator in order to solve the main problems that various authors have encountered when measuring levels of efficiency in CE, so that without adequate knowledge and indicators, measuring the impact of CE on efficiency will always be limited (Winans, K.; Kendall, A.; Deng, H,2017). Linder et al. highlight the urgent necessity to carefully analyze the present techniques for assessing circularity in order to discover answers to its many flaws or to establish some complementarities (Linder,2017).

In response to the rising number of diffuse and complicated indicators in a CE, the purpose of this section is to illustrate, via an intensive bibliographic study, the several steps that researchers and entrepreneurs must consider in order to appropriately characterize this type of indicator: First it describes how to establish an indicator; next it outlines the dimensions that must be considered in order to define that indicator; and last, it analyzes the many limits that researchers have faced when assessing CE.

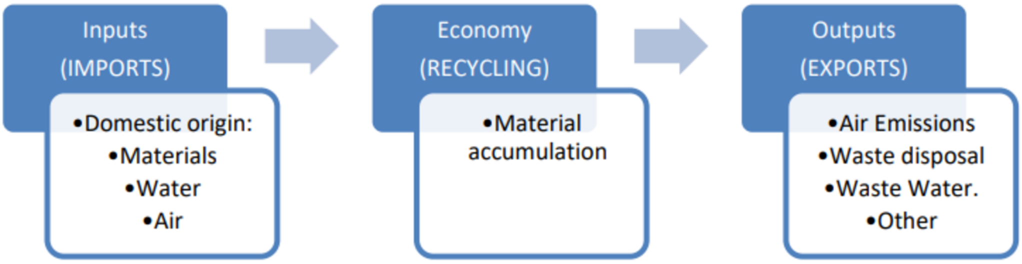
In particular, with regard to CE, indicators must be aimed toward CE practices in order to truly quantify the intended impact on efficiency as a springboard for a transition to the implementation of new CE practices (Kalmykova,2018). As a result, their many potential applications (Linder, 2017), the degree of performance they report, and the influence of legislation on this sort of activity should be considered as key performance indicators. (Thomas, J.S 2013) Due to the complexities of quantifying these indicators, the researcher must rely on the interdependence of the various stages of the company's value chain, producing indicators that encompass the implementation of these activities (Verberne J., 2016).

3.2.4 Selection of Indicators for Measuring Efficiency in the Circular Economy

The European Commission emphasizes the significance of building a monitoring system aimed at measuring progress toward CE in a way that encompasses all parameters at all stages of the life cycle of resources, goods, and services. (European Commission,2017) The framework for monitoring should include a collection of indicators organized into four categories and components of the circular economy: (1) production and consumption, (2) waste management, (3) secondary raw resources, and competitiveness and innovation are all addressed. This is largely consistent with the rationale and structure of the CE action plan.

The CE's manufacturing process, i.e., the entire material flow balance, must be considered while developing these indicators.

Figure 2:Material flow balance method simplified (including air and water)



Source: European Commission

Indicators that incorporate these goals are thus required for this new management approach. It would be a management approach that aids decision-making by focusing on stable and sustainable growth and the recovery of waste and by-products that produce new lines of business or are reincorporated into previously existing production processes. As a result, each participant will want indicators that focus on various topics based on their demands. And from the other hand, while developing a set of indicators to evaluate CE, several levels must be considered: micro-, meso-, and macro-:

- At the micro-level, each firm must develop a set of customized indicators based on the company's features, conditions, and current difficulties. Indicators based on the three Rs of trash (reduce, reuse, and recycle) are commonly employed, but not on CE in general.
- The idea on which measurement focuses at the meso-level is industrial symbiosis, which consists of the use of common infrastructures and services, i.e., indicators that help manage the performance of plants and industrial parks.
- Lastly, at the macro-level, indicators must be developed to assess, monitor, and improve policies (European Commision,2018).

To construct an indicator system at any of the preceding levels, we must follow a certain procedure. For the verification of a CE approach, Valerio, Grazia-Gnoni, and Tornese recommend the following procedures:

1. Examine the system and processes that will be examined. This might represent a single process, a series of processes, or the full supply chain. A zero-waste plan, for example, focuses on ultimate resource management.
2. Select which requirements to measure by identifying the actions that will be used to identify which requirements to measure.
3. Select the approach to be used (E.Valerio, 2017).

To do so, it is necessary to examine the business models of organizations participating in CE, because a business plan is a conceptual instrument that can be used for analysis, performance assessment, comparison, management, communication, and innovation (Osterwalder, 2005).

3.3 Theoretical aspects of waste management

By the end of the 20th century, there was a new direction of human activity in the world, which in world practice was called "Waste Management". Although the emergence and rapid development of this type of activity was less noticeable than, for example, computer science, this event can be called revolutionary, indicating a leap to a new level of consciousness.

The term "waste management" in the established world practice refers to the organization of waste management in order to reduce their impact on human health and the environment, and "waste management" is defined as the activity in which waste is generated, as well as activities for the collection, use, disposal, transportation, disposal of waste".

The first legislative document in the field of waste management is the European Union Directive 75 \ 442\ EEC of July 15, 1975, which for the first time formulated and legislated the principles of waste management - the so-called Waste Management Hierarchy.

Figure 3:Diagram of the waste management Hierarchy

Source: http://gbbinc.com/services/sustainability

The waste management hierarchy - a universal model for handling any type of waste - is a classification of waste management actions according to their priority level and is based on the following principles:

1. prevention or reduction of waste generation;
2. division of waste at the source of its formation;
3. reuse of waste by returning to the production process;
4. recycling - processing of waste in order to obtain new types of raw materials or products from them;
5. neutralization of waste in order to reduce its danger to the natural environment;
6. disposal of waste is the least preferred alternative to waste management.

In 1996, the EU member states adopted the main policy document in the field of waste management, the EU Waste Management Strategy, which served as the basis for the adoption of similar legislative documents in all European countries. In accordance with the EU VI Environmental Program adopted on 22 July 2002, waste management is one of the four priority areas of European countries environmental activities.

The principles of the waste management Hierarchy were legislated at the international level at the International Conference on Sustainable Development in Johannesburg in September 2002, at which the improvement of the waste management system was recognized as the main problem in the field of environmental protection. At the conference, it was emphasized that the main strategic goal of the world community on the path to sustainable development is to destroy the link between economic growth, resource use and waste generation. The hierarchy of Waste Management, which was legally established in the framework of European and later international law, gave rise to the emergence and rapid development of a new industry - the waste management industry, called the waste management industry.

The necessity to organize waste management arose as a result of the conflict between human production activities and the natural environment, which led to a violation of the stability of the biosphere. Therefore, the emergence of this direction of human activity is not accidental and can be considered as a consequence of the natural evolution of the biosphere on the way to its transition to a new stage of development - the noosphere, which implies a reasonable regulation of relations between man and nature.

According to V. I. Vernadsky's theory, human production activity is a part of the biosphere, and the technology created by it is not something alien to the biosphere, but a qualitatively new stage of its development. The biosphere is a global terrestrial ecological system consisting of many diverse ecosystems. Man-made machines, enterprises, industries, etc. are also part of the biosphere and can be defined as man-made ecosystems, or techno ecosystems. While biological processes take place in natural ecosystems, industrial technological processes are implemented in techno ecosystems along with natural biological ones. Ecosystems are created during the evolution of the biosphere; techno ecosystems are formed by man as a result of his evolution and the evolution of the biosphere of which he is a part. However, the evolution of ecosystems does not disrupt the balance of material and energy flows between living organisms and the environment. As V. I. Vernadsky wrote, " between the stagnant lifeless part of the biosphere, its stagnant natural bodies and the living substances that inhabit it, there is a continuous material and energy exchange, materially expressed in the movement of atoms caused by the living matter. This exchange in the course of time is expressed by a naturally changing, continuously striving for stability equilibrium". The development of techno ecosystems, as Vernadsky put it," at a rate comparable to the multiplication in geometric progression " led to a colossal disruption of the balance of material and energy flows between them and the environment by the end of the second millennium, which resulted in a growing increase in pressure on the biosphere, its exit from a stable equilibrium state, the destruction of natural ecosystems, local and global environmental disasters.

Since, according to the theory of V. I. Vernadsky, humanity cannot stop in its movement, and "the course of scientific thought in creating machines is similar to the course of reproduction of organisms", it is impossible to stop the creation and development of techno ecosystems, but it is necessary to ensure their safe development for the biosphere. And everywhere close to a person can see perfect examples of this development are the natural ecosystem. An ecological system is a spatially defined set of living organisms and their habitat, united by material, energy and information influences. In a natural ecosystem, material and energy flows are used with maximum efficiency, and the minimum possible amount of waste generated is effectively recycled, which ensures its maximum isolation. However, there are no completely isolated systems in nature, and some of the waste generated in natural ecosystems enters the environment, where it accumulates. But, for the disposal of these wastes, there are natural mechanisms that ensure their safety for the environment, and the substances and energy contained in the accumulated waste are buried in the bowels of the Earth and do not violate the stability of the biosphere. Each natural system is an ordered self-regulating system. We can say that within natural ecosystems there is a management system that ensures their self-organization and evolutionary development, which does not violate the stability of the biosphere.

The management of waste generated as a result of the vital activity of living organisms inhabiting this ecosystem is considered by us as part of the overall management system of the natural ecosystem. Ecosystem waste management is essentially the management of material and energy flows through information interaction between the components of the ecosystem - its individual cells - and the environment, ensuring the self-organization of the ecosystem and its sustainable development. The presence of such a management system determines the ability of ecosystems in the course of evolutionary development to increase the concentration of information or the degree of their organization. And the higher the level of information, the higher the degree of use of material and energy flows. As R. Margalef notes, " life prefers information over the flow of energy."

3.3.1 Waste management in Europe

The European Union Waste Management Strategy aims to implement a sustainable development agenda for Europe. The concept included in the strategy provides a set of rules and principles for waste management and defines the waste management procedure. According to the new Framework Directive 2008/98/EC of the European Parliament and The European Council "On Waste", which was implemented in Swedish legislation in the summer of 2011, at the heart of the modern European waste management system, a five-stage system of priorities is defined:

- prevention of waste generation;
- reuse;
- recycling and reuse;
- use as energy resources;
- disposal in landfills.

At the top of the hierarchy is waste prevention. In companies at various levels, for example, this approach is reflected in the concept of lean production, the "Cradle to Cradle" principle in packaging design (Filippov, Kadirov, 2015). Reuse refers to putting things that have already been produced back into useful circulation. A classic example is the reuse of glass containers. On the third level of the hierarchy is recycling and reuse. For those living in the European Union, recycling has become the mainstay of waste management. Due to the high degree of negative impact on the ecological system, the least preferred methods of disposal are the use of waste as an energy source, usually incineration, and landfill.

As can be seen from the description, recycling has a higher priority than landfill disposal or the use of waste as fuel. EU countries are obliged to design their national waste management systems on the basis of a fixed hierarchy. Recycling and reuse is, for example, central to European waste management systems. Recycling-oriented systems, in addition to improving the environmental situation, allow waste to be used as raw material in the production of goods.

The efficiency of recycling is directly related to the quality of incoming waste. To improve it, incoming waste must be sorted, i.e. the total waste stream must be divided into its component parts (fractions). In EU countries the function of primary sorting is transferred to waste generators, and only later the final separation takes place in processing plants (EU, 2021) This approach achieves a high recycling rate due to the higher purity and homogeneity of the incoming fractions. Those wastes that are not recyclable are usually sent to landfill or incinerated in incineration plants. The experience of some countries in organising waste management systems is presented below.

Figure 4:Municipal waste generated 2005 and 2020

Source: Eurostat

3.3.2 Waste incineration

Theoretically, waste can be considered as fuel, and waste incineration plant, respectively, as heat stations. In practice, the situation is not so good. First, the calorific value of waste that has not been separated is very low. Simply put, they may not burn at all in the air (this depends on the content of non-combustible fractions in MSW and the humidity that changes due to weather conditions). Complete combustion may require additional drying, the use of real fuels, or the use of an oxygen-rich gas mixture as an oxidizer instead of air.

Incineration still doesn't eliminate the waste problem. The incombustible slag remaining in the furnaces and the ash caught in the treatment plants account for up to 10% by volume and 30% by weight of the initial amount of MSW that "entered" the gate of the incinerator plant. This slag and ash still need to be put somewhere. And often this requires not landfills for the disposal of solid waste, but because of their high toxicity in special landfills.

The disadvantages of the waste incineration plant are the high cost of equipment, much more complex, compared to conventional heat stations, the technology of burning and cleaning gases, poor extraction of useful components. Even considering all sorts of tricks (pre-sorting, useful use of the resulting heat and slag), waste incineration plants are rarely profitable enterprises. Nevertheless, despite all the shortcomings, there are more than a thousand waste incineration plants operating in the world, although recently there is a tendency to reduce them.

As for the commercial feasibility of solid waste incineration, there are different opinions on this matter. Some believe that waste incineration plants are competitive with other options for solid waste disposal. The total operating and capital costs of a modern waste incinerator are about $ 100 per ton of solid waste but taking into account the profit from the sale of electricity and steam, burning a ton of garbage costs the plant in the range of $ 10-40, and this is already attractive for those who bring garbage to the plant and pay for its destruction.

Another opinion is held by opponents of solid waste incineration, who believe, and not without reason, that MSW harms the environment. The first waste incineration plant was built in England in 1874, but only a hundred years later, dioxins were discovered in the waste gases of the waste incineration, and research began on the harm that waste incineration causes to the environment and human health (Yufit,1999).

Heavy dust particles from waste incineration, in which dioxins are well adsorbed, fall out just in the area adjacent to the waste incineration plant pipe, but smaller particles carry dioxins over long distances. Here are the data from studies conducted in Japan near one of the waste incinerations plants, however Japanese waste incineration plants are among the best in the world. In a radius of up to 1.1 km, 42% of those who died in 1985-1990 died of cancer, and in a zone of 1.1 to 2.0 km – 20%. The last numeric was close to the average for this region. The Dutch showed that even at 24 km, dioxin pollution can be traced. They are dangerous at very low concentrations-fractions of nanograms per cubic meter. In the waste gases of the waste incineration plant of Canada and the Netherlands (1987-1990), 0.063-0.597 micrograms of dioxins per cubic meter were present (Yufit, 2001).

Dioxins also get into the slags from the combustion of waste, and they are formed about a ton for three to four tons of garbage. These slags are used to make curb blocks and blocks for construction, and they are added to the asphalt. Craftsmen offer make them a slag wool for thermal insulation of buildings. This means that the poison will go not only to the grandchildren, but also to the great-grandchildren.

Where do these dioxins come from? In fact, an incinerator is a factory for the production of toxic waste. Modern waste can include a significant amount of chlorine-containing organic matter. During their "thermal utilization", more than a thousand toxic substances are produced. The most dangerous of them are dioxins.

When burning one kilogram of polychlorobiphenyls or polyvinyl chloride, which is used to make many types of linoleum, wallpaper, window frames, electrical equipment, and plastic containers, up to 50 micrograms of dioxins are formed. These are extremely carcinogenic poisons, according to scientists, which are almost a thousand times more toxic than such chemical warfare agents as sarin and soman. The lethal dose for a person is nanograms per kilogram of weight.

In countries with developed environmental legislation, up to half of the capital costs for the construction of incineration plants go to the installation of air purification systems, and up to 1/3 of the operating costs-to pay for the disposal of ash. But even the most modern cleaning devices can't exclude the contamination of the air with dioxins.

The way of incineration of waste, firstly, is not environmentally friendly. Secondly, it is extremely expensive and uneconomical, not only in terms of construction costs, but also in operation in compliance with all sanitary standards. This is an illusion that a furnace running on low-calorie, wet fuel is able to solve the problem of waste and eventually pay for itself. Third, the option of burning solid waste is simply outside the current trends, the main feature of which is resource and energy saving.

Over the past 10 years, there has not been a single case of construction of an incinerator in Europe, and many old waste incineration plants have been closed because they do not meet the requirements of the EEC standards in terms of emissions. It is important to note that in developed countries, not everything is burned, but only what remains after sorting and recycling.

Taking into account the factor of dioxin formation and the technological difficulties of their elimination, several new, very strict standards for waste incineration plant emissions were adopted in the European Economic Community (EEC), the USA and Canada in the early 90s. The consequence of these decisions was the closure of hundreds of waste incineration plants. Only in the Netherlands, for example, a third was immediately closed, in the United States in the mid-90s, about 20 plants were closed, and in England the creation of new waste incineration plant was banned because of their environmental danger. In some places, they were reconstructed, which mainly concerned systems for cleaning and enriching the blast with oxygen, which cost millions of US dollars.

Only small countries (Denmark, Switzerland, the Netherlands), where there are absolutely no places for disposal, continue to use this technology for the destruction of household waste, but they spend huge amounts of money on cleaning the waste gases from dioxins or use modern incineration technologies so that they do not form. However, it should be clarified that in these countries, too, only those wastes from which a part of the useful fractions has already been selected are burned.

Only Japan stands out, which fans of this method like to cite as an example. In this country, three-quarters of all household garbage is burned and a huge number of factories and factories (1900), although well-equipped, smoke. However, the experience of the Japanese is practically not suitable for us. This is an island country, and with any wind rose, everything flies into the open ocean, while there is practically no land available for burial. And, of course, the Japanese do not consider as waste what can be immediately extracted and profitably processed into a product that has demand (Itoh, 20014).

In Russia, the first incinerators built according to the Czechoslovak project appeared in the early 70s. The heat generated by the combustion of the waste was not used to produce either steam or electricity.

The smaller the country, the less space it has for landfills and landfills. Therefore, in Japan, Switzerland, and Denmark, most of the garbage is burned. A total of 388 such plants are currently operating in Europe (European Commission1 2018). In Japan, which has 1,900 MSPs, there is one plant for every 200,000 people.

However, it should be clarified that in these countries, too, only those wastes from which a part of the useful fractions has already been selected are burned.

3.3.3 Global experience in the fight against waste

According to the World Bank, humanity annually produces just over 2 billion tons of municipal solid waste (MSW). By 2050, this figure threatens to grow to 3.4 billion tons.

Italy

Almost the entire territory of the country has a separate garbage collection-again, somewhere to a greater or lesser extent. In the country, it is necessary to separately collect clean paper and cardboard, plastic and metal, organic waste, and non-recyclable garbage, as well as glass. Each type of garbage has its own container, which is exported on certain days. As for the fee for garbage collection, each city administration sets its own tariffs. As a rule, they are calculated considering the number of registered people in one living space and range from €150 to almost €600, but on average - €300 per year. A large family pays more than a single person. At the same time, in the south, tariffs are higher, although the average income of the population here is less than in the north — €600-700 against €1000 in the country (Bianchi, 2018).

There are no general benefits and incentives. On the contrary, the removal of large-sized garbage is carried out for an additional fee by private companies. Individual items — washing machine, wardrobe, mattress - can be picked up free of charge by the municipal services.

And for garbage thrown out in the wrong place, large fines are provided — up to several hundred euros. Nevertheless, in Italy, there are landfills along secondary roads. A particular problem is observed with plastic, which is littered with everything, including beaches and seacoasts. In general, in Italy, there is a very heterogeneous situation — somewhere the service of garbage collection and disposal is better, somewhere worse. It is enough to recall the loud "waste scandals" in 2007 in Naples.

Rome is now on the verge of a garbage collapse. In the capital, the garbage collection service is not called anything other than a disaster: the schedule for the removal of a particular type of waste is not observed, full containers are standing on the street, and everything is thrown out in them. And in the summer, due to high temperatures, the situation only worsens. Other regions that are doing better are coming to the rescue. But this does not change the situation dramatically. One of the model regions in terms of waste disposal is the island of Sardinia, where several incinerators of the latest generation operate. In total, 39 incinerators operate in the country, which in 2017 disposed of 18% of waste and produced 4.5 million MW of electricity and 2 million MW of heat. About 27% of the waste is recycled by the Italians to produce new materials, and the rest goes to composting and underground disposal (Sospiro, 2017)

In Italy, there is a lot of talk about the problems of pollution, about the need for a more responsible approach to waste collection. In different parts of the country, the level of civic consciousness is different — as a rule, the inhabitants of the north are more responsible. The authorities are trying to close the landfills, but there is no real alternative at the national level yet. In total, there are 127 landfills in Italy.

China

The country has been trying to solve the problem of recycling and recycling of garbage for several years. Recently, this issue has become particularly acute due to the increasing environmental threat affecting the overall economy of the state. Since 2009, the country has adopted a law aimed at meeting the regulatory requirements for the processing of industrial and household waste, as well as the disposal of non-recyclable waste. That, however, does not stop the emergence of huge, slightly disguised landfills at the exit from large megacities.

On the streets of Chinese cities, tanks with two or three types of containers are installed — for recycling, non-recyclable waste, and food waste. Sometimes they add separate tanks for plastic and glass.

But despite the possibilities for sorting, garbage in China is often thrown out on the principle of "which container is closer". Because today in the country there is no concept as such of social responsibility for improperly discarded garbage, as there are no fines for the population for throwing a plastic bottle into a compartment for food waste. This issue is "regulated" by the personal conscience of everyone. But for legal entities, the punishment is gradually introduced.

As for the sorting of garbage by the Chinese themselves in residential buildings, this experience is also not yet too developed. But the authorities of some cities are taking active measures to instil this useful habit in the population. For example, in Shanghai, about 3.8 million families in the city have now signed up for a program that allows them to accumulate points for properly sorting garbage, and then exchange them for some food, utility bills, and mobile communications. For those who are interested in material rewards, China also installs special machines for recycling plastic bottles — for one handed over container, citizens are charged 0.05 yuan (less than 1 cent) (Clean Energy,2017).
In China, along with numerous firms that specialize in collecting, sorting and disposing of waste, as well as dismantling landfills and sending suitable raw materials for recycling, garbage collectors remain an important part of the system. It is they who sort out the pile of household waste piled up in a common pile by ordinary citizens and sort them depending on their further purpose. At the same time, in China, a garbage collector is an honorary profession, whose representatives are loved and respected.

According to the Ministry of the Environment of the People's Republic of China, currently about 90% of China's garbage is disposed of by incineration or by taking it to landfills. But along with recycling its own garbage, since the 1980s, China has been importing solid household waste as a source of raw materials, and the EU and the US remain the main suppliers. According to the Ministry of Commerce of the People's Republic of China, in 2017, the processing industry became the second largest employer in the country after agriculture.

Since 2017, the country has started to restrict the import of foreign recyclables due to increased environmental hazards. The Chinese Foreign Ministry noted that " the government's future plans are aimed at developing an advanced processing industry that will help to cope with the problem of waste disposal within the country."

India

India needs a general clean-up. But this was not always the case, and in fact, dirt on Indian streets is a fairly new phenomenon, according to urban experts. They explain the problem by tradition — in India, traditionally, waste was thrown out just on the street. But if earlier the heat and the sun dried them into dust, then they can no longer cope with the plastic, cardboard and other modern products that appeared in the XX century. This is aggravated by the migration of the rural population to the city, which continues to throw garbage on the streets in the old way.

The total mileage of all landfills in India, according to estimates of the Indian non-profit organization Waste Ventures India, by 2047 will be 1.4 thousand square kilometres, which is approximately equal to the area of the three largest cities in the country — Hyderabad, Mumbai and Chennai.

Another important problem is that India is just beginning to organize a modern system of waste collection and disposal. At the same time, the scavenger's profession remains caste-based, the Dalits — untouchables-are engaged in garbage. The men take the waste directly to the neighbourhoods where they live twice a day — in the morning and in the evening. And the women sort it, taking away plastic bottles, wastepaper, scrap metal, glass, rags, discarded clothes and shoes. All this is then sold. But if something is not suitable for garbage collectors, it often remains on the streets.

Cleaning companies also employ people from lower castes, who often protest any changes in the system that threaten them with unemployment. In other words, the waste collectors are blackmailing the authorities with a social explosion, but they are clearly failing to clean up the streets properly. Due to the lack of a modern waste disposal system and its caste-based nature, there is no single fee for garbage collection in India. It varies depending on the city or district.

Previous Indian governments since the 1970s have repeatedly tried to change the attitude of citizens to waste. The current government of Prime Minister Narendra Modi has taken the most decisive approach to the problem of garbage on the streets. In October 2014, he launched the campaign "Swachchh Bharat" ("Clean India"), according to which the image of the country should change in five years. The symbol of the campaign was Gandhi's round glasses, through which, Modi said, " The Mahatma is watching us clean up India." The participation of the Prime Minister himself, Bollywood movie stars, major entrepreneurs, government officials, and even a few billionaires improved the situation, but not radically.

Nevertheless, the authorities are not going to give up. The government has announced a program for India to eliminate single-use plastic products by 2022. A draft law banning the import of such products is now being considered.

In addition, since 2016, the Waste to energy recycling program has been implemented in the country, according to which about 80 incinerators operate. The government plans to build another 100 incinerators.

In New Delhi, they understand that one high-profile campaign will not solve the problem of garbage-you need to act gradually and purposefully.

Mexico

The volume of garbage production in the country, according to the Ministry of Environmental Protection and Natural Resources, reached 117 thousand tons per day by the end of 2017. Thus, Mexico has reached one of the first places in the generation of waste in Latin America, according to the UN.

Even though there is more and more garbage in Mexico every year, the situation with its collection, not to mention processing, remains consistently difficult. According to the former head of the environmental ministry, Raphael Pacciano, up to 70% of the waste is not even sent to landfills or landfills, but falls directly into rivers, forests and ravines.

The initiative proposed by Semarnat in late 2016 to charge 90 pesos ($4.6) per month to each Mexican family for garbage collection has not yet been widely adopted. It cannot be denied that one of the major obstacles to its implementation has been and remains the low standard of living of many Mexicans.

3.4 Econometric analysis

Econometric methods allow us to build models of relationships in the economy, quantify the dependencies reflecting these relationships, and use the estimates obtained either to predict or to explain the internal mechanisms of the studied economic phenomena. The term "econometrics" was introduced in 1930 by the Norwegian scientist Ragnar Frisch, winner of the Nobel Prize in Economics, and reflects the content of econometrics as a science. This term is a combination of the terms "economics" and "metric" and means "measurements in economics".

Econometrics is a science in which mathematical models of mass economic phenomena are built on the basis of economic theory and real statistical data in order to quantitatively confirm or refute certain economic hypotheses and predict the corresponding economic indicators. As follows, the object of econometrics research is real economic processes, and the subject of its research is quantitative characteristics of interrelations in the economy (Kremer, 2008).

Correlation and regression analysis are the primary research methods in econometrics. As a result, may describe the steps of econometric study.

- problem statement;
- data acquisition, analysis of their quality;
- model specification selection;
- selection of factors;
- evaluation of parameters;
- checking the reliability of the received parameters;
- interpretation of the results.

The list includes the stages that any study goes through, regardless of whether it is focused on the use of spatial or temporal data (Yufereva, 2002).

The econometric model is a form of representation of the relationship of economic indicators in the form of the sum of two terms, the first of which reflects the influence of selected factors on the effective feature, and the second - the influence of random variables.

The general formulation can be formulated of the econometric modelling problem. It consists in the following: according to the available data, n observations of the change in the attribute y, depending on the sets of values of the factors $x_1, x_2, ..., x_m$ choose an econometric model $y= f(x_1, x_2, ..., x_m) + \varepsilon$, evaluate its parameters and statistically substantiate that the factors $x_1, x_2, ..., x_m$ are essential, and the constructed function $f(x_1, x_2, ..., x_m)$ is such that most accurately corresponds to observational data (William,1990).

3.4.1 Multiple regression

Multiple linear regression is expressed as a direct dependence of the average value of the value Y on two or more other values $x_1, x_2, ..., x_m$. The value Y is usually called a dependent or resultant variable, and the values $x_1, x_2, ..., x_m$ are independent or explanatory variables (William,1990).

In the case of multiple regression analysis, it is necessary to evaluate the coefficients of the equation

$$y = \beta 0t + \beta_1 x_1 + \beta_2 x_2 + ... \beta_n x_n + \mu t, \qquad (1)$$

where y is the number of independent variables denoted as x_1 and x_n, and a is some constant.

Variables declared independent may themselves correlate with each other; this fact must be taken into account when determining the coefficients of the regression equation in order to avoid false correlations.

3.4.2 Autocorrelation

Autocorrelation (sequential correlation) is defined as the correlation between the values of the observed variable, ordered in time or in space. Autocorrelation can be positive and negative.

Among the main reasons causing the appearance of autocorrelation, one can distinguish:

- the model does not take into account any important factor (input variable) or the wrong choice of the type of response function (this leads to deviations of experimental points from the regression line, which can cause autocorrelation);
- cyclical values of economic indicators;
- averaging of statistical data by intervals;

- the delay in changing the values of economic indicators in relation to changes in economic conditions.

Autocorrelation, if ignored, worsens the predictive qualities of the regression model. The presence of autocorrelation can be established using rank correlation methods.

The most well-known method for detecting autocorrelation is the Durbin-Watson test, which is used to identify the presence of autocorrelation in regression residuals, is one technique to see if this condition is satisfied.

$$d = \frac{\sum_{t=2}^{T} (e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^2} \tag{2}$$

Where $e_i = y_i - \hat{y}_2$, and y_i , $\hat{y}_2$ are respectively, the observed and predicted values of the response variable for individual *i* . *d* becomes smaller as the serial correlations increase. Upper and lower critical values d_U and d_L have been tabulated for different values of *k* (the number of explanatory variables) and *n*.

3.4.3 Heteroskedasticity test

The phenomenon of heteroskedasticity occurs, as a rule, when analyzing heterogeneous objects. For example, when constructing the dependence of a firm's profit on the size of the main fund (or any other factors), heteroscedasticity is caused by the fact that large firms will have higher profit fluctuations than small ones.

The **Breusch-Pagan-Godfrey Test** is a regression error heteroscedasticity test. Heteroscedasticity means "differently distributed," in contrast to homoscedasticity, which means "same scatter." Homoscedasticity is a crucial assumption in regression; if it is violated, the result will be unable to conduct regression analysis.

$$\chi 2 = n \cdot R2 \cdot k \tag{3}$$

Where:

n = number of samples

R^2 = R^2 (Coefficient of Determination) of the squared residuals regression from the initial regression.

k =denotes the number of independent variables.

3.4.4 Normality test

The normality tests enhance the graphical evaluation of normality (Elliott, 2007). The test compares the sample scores to a regularly distributed set of scores with the same mean and standard deviation; the null hypothesis is that the "sample distribution is normal," and if the test is significant, the distribution is non-normal. Normality tests have low power to reject the null hypothesis for small sample sizes, hence tiny samples frequently pass normality tests (Oztuna, Elhan, 2006). Significant findings could be obtained for high sample sizes, on the condition that there was a minor departure from normality, however, this tiny variation would not alter the results of a parametric test (Field, 2009).

4 Practical Part

4.1 Overview of the economy of Sweden

The Kingdom of Sweden is located in Northern Europe, in the eastern and southern parts of the Scandinavian Peninsula. The territory is 447,435 km2, and the population is more than 10 million people - according to these indicators, it is the largest Scandinavian state. Among the European states, it occupies the 5th place in terms of territory. The capital is Stockholm. The official language is Swedish

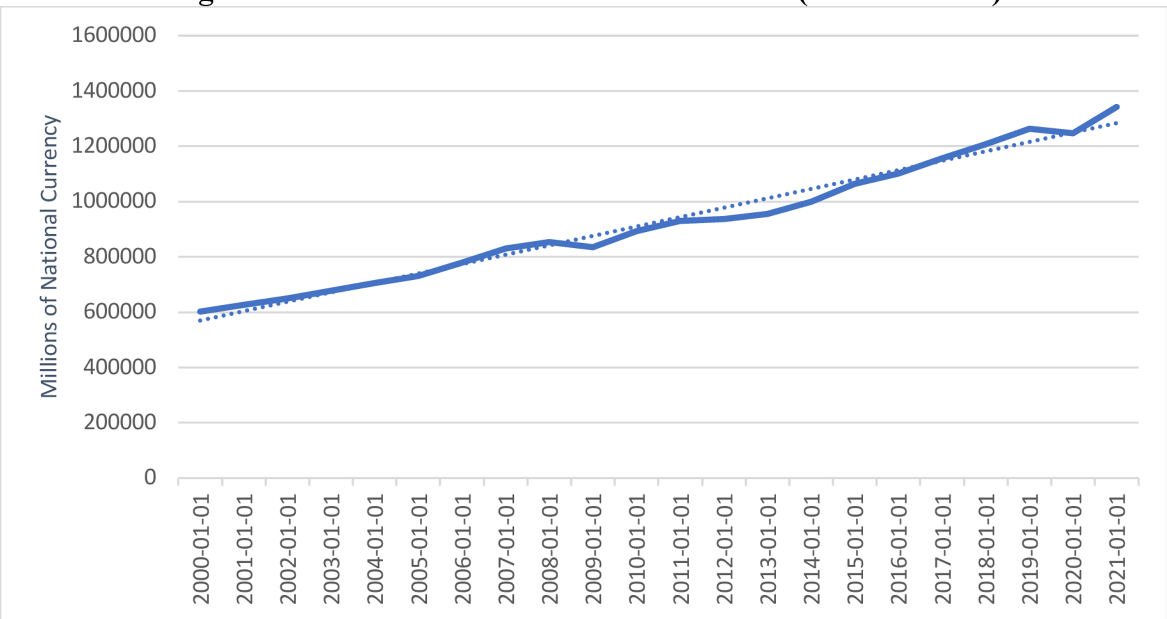
Sweden is a highly developed Scandinavian country, a leader in Europe in many ways. These are: labour productivity, labour force qualifications, flexibility of the country's economic policy, high competitiveness of the country in the global economy. Sweden developed unevenly in the XX century. For a long time, it was a rather backward state with a lot of socio-economic problems. The 1960s of the XX century were the time of the rise of the Swedish economy. GDP growth has accelerated markedly. In general, in the XX century. Sweden has gone from poor an agrarian country with an undemocratic parliament to an advanced post-industrial power that has become one of the centres of information technology, a modern rule of law state with a stable socio-political system.

In the 20th century, what is often called an "economic miracle" happened in Sweden. Within just a few decades, a poor agrarian country has turned into one of the richest and most highly developed industrial powers. The basis of this unprecedented development was the vast natural resources of northern Sweden - timber, ore and hydropower resources - combined with a number of revolutionary Swedish inventions and their further development and operation, such as steam turbine, ball bearing, gas beacons AGA, telephone, milk separator, safety match, adjustable pitch propeller, packaging "tetrapak" and many others. Even to this day, the industry created by a technical genius remains the core of the Swedish national economy. Due to the narrowness of the domestic market, large Swedish companies had to focus on opening other markets and exporting at an early stage. It is believed that in many cases this early globalization gave Swedish companies advantages in international competition. Thanks to this, Sweden today has extremely high rates in terms of the number of large multinational concerns and well-known trademarks in proportion to the size of its population: Volvo, Saab, Erikson, AstraZeneca, Electrolux, Ikea, Hennes and Mauritz, Hasselblad, - here just a few of them.

GDP

The Swedish economy experienced a severe economic slump in 2000 as a result of the fall of the IT industry in the early year of 2000, following years of economic development. The economic crisis was followed by an economic boom as global commerce rose dramatically, resulting in a quick increase in Sweden's export growth. Volume increase in Sweden reached 4% between 2004 and 2006. Nevertheless, economy has slowed again in 2007. The financial crisis caused a serious recession in the latter part of 2008. GDP growth slowed in 2009 before rebounding somewhat in 2010 (Eurostat).

Figure 5:Gross Domestic Product for Sweden (SEK Millions)



Source: FRED Economic Data

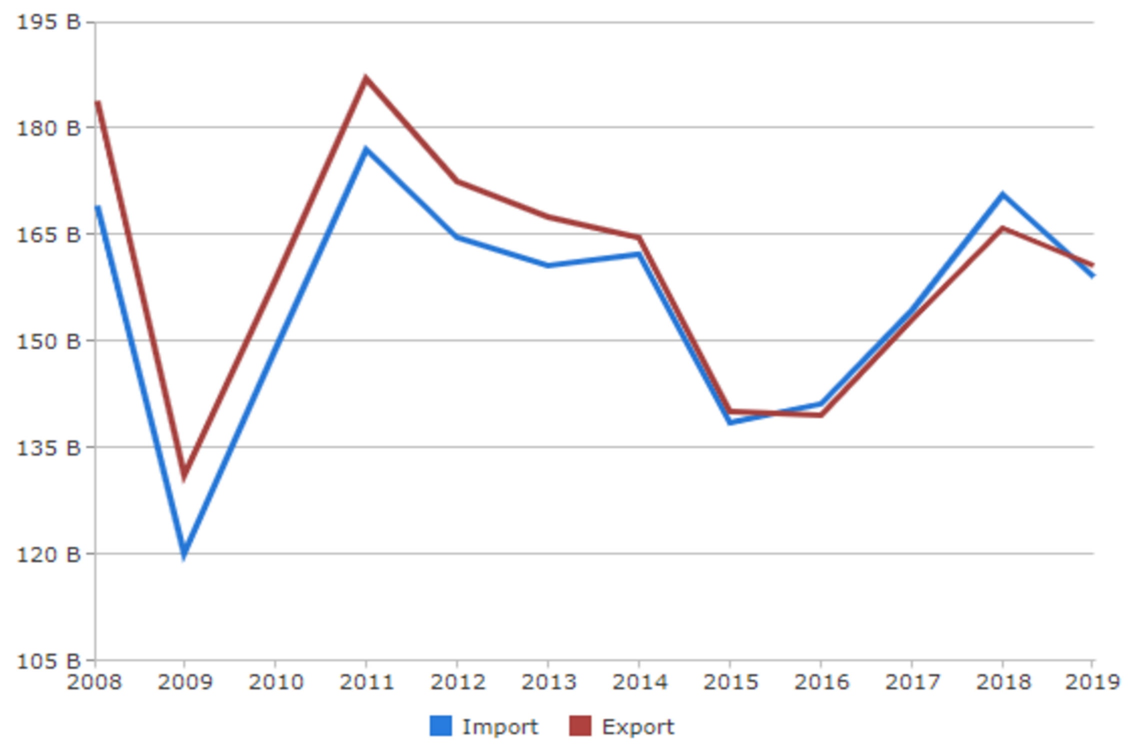
After the financial crisis, the Swedish economy began a strong recovery with the highest growth rates since 1970.The country's economy has slowed down again due to the debt crisis in the eurozone countries. GDP is growing very weakly over the next few years. In 2013-2019, Sweden 's GDP in current prices decreased by 9.5%, the change was due to an increase in the population by 0.42 million. Sweden's average annual GDP growth was -1.7%. The average annual growth of Sweden's GDP in constant prices was at the level of

2.5%. The share in the world decreased by 0.15%. The share in Europe decreased by 0.22%. As of 2021, Sweden's GDP raised by 4.8% more than last year.

Export and Import

Since the mid-1980s, Sweden has exported products and services at a higher value than we have imported, as shown by the graph. This indicates that Sweden makes more money through exports than it does from imports. The disparity adds to a rise in gross domestic product (GDP) and economic growth in Sweden. It is referred to as having a positive current account. In this situation, commerce in goods and services includes merchanting and is derived from the Payment Balance's computation of trade in goods and services.

Figure 6: Export and import of Sweden (2008-2019, in billion SEK)



Source: Statistics Sweden

Sweden's productivity growth was faster than that of many other OECD nations from 1995 towards the mid-2000s. During this time, Swedish firms developed their activities in global value chains. Global studies have demonstrated that importing intermediate commodities and services increases both productivity and salaries in businesses (Halpern, 2015).

However, economic development has been exceptionally low in both Sweden and the rest of the globe since just before the crisis (Gordon, 2019).

4.1.1 Achievements of Zero Waste in Sweden

In 1999 the government of the Sweden adopts a list of 15 environmental goals that are designed to make the state clean and favourable for people. Clean air; high-quality groundwater; sustainable lakes and riverbeds; natural state of wetlands; balanced marine environment, sustainable coastal areas and archipelagos; no eutrophication; only natural oxidation; richness and diversity of forests; stable agricultural land; majestic mountainous areas; good urban environment; non-toxic environment; radiation safety; protective ozone layer; reduced impact on climate — these goals look clear and clear, but they are not so easy to achieve.

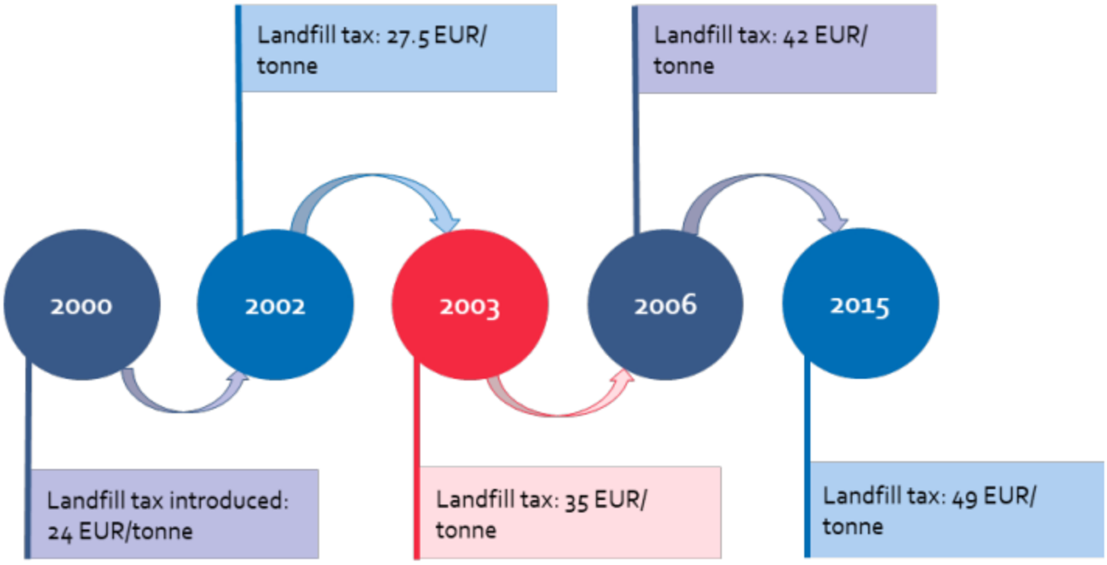
According to the local waste management association Avfall Sverige, 99% of household waste is disposed of in Sweden (Avfall, 2019). This is one of the highest rates in the world. At the same time, the Swedes have learned how to effectively turn garbage into energy. Almost half of the waste in the country is incinerated — but only after careful sorting. plastic, paper, and food waste go to processing or biogas production.

The restoration of the useful qualities of waste is a priority. First of all, the Swedes seek to reuse them, recycle them or turn them into an energy source. Landfill burial occupies the last place in the hierarchy — only the garbage gets to the landfill, with which nothing else can be done at all.

For the first time, the 1991 Environmental Objectives System established goals for overall environmental policy in Sweden. The goals were to safeguard human health, conserve biodiversity, and decrease the exploitation of resources therefore that has been used in the long run while in addition protecting natural and cultural landscapes.

The government put a charge on waste delivered to landfill in 2000, which was 250 SEK/tonne (about 24 EUR/tonne). Since its inception, the landfill tax rate has been gradually increased, increasing to SEK 288 or 27.5 EUR/tonne in 2002, SEK 370 or 35.2 EUR/tonne in 2003, SEK 435 or 41.4 EUR/tonne in 2006, and SEK 500 or 49 EUR/tonne since 2015. Figure 7 depicts the evolution of the landfill tax rate throughout time (Avfall, 2016).

Figure 7:Timeline of Swedish Landfill Tax



Source: Statistics Sweden

The disposal of waste restrictions was revised in 2008 as a result of the introduction of the EU battery directive. As a result, batteries that have not been processed under specific requirements of the waste code may not be landfilled or burned, and as such, batteries have been included as a waste category that may not be landfilled.

Priorities listed in the 2005 Swedish National Waste Plan included moving the plan's attention to minimizing the hazardousness of trash and the amount of dangerous waste. It also aimed to improve Sweden's understanding of environmental threats. Other goals included making recycling easier for Swedish homes and increasing Swedish participation in EU trash work.

In 2011 the Swedish waste ordinance includes waste and waste management rules, as well as certain fundamental terminology for Swedish waste policy. It governs the disposal of combustible garbage, hazardous waste, and organic waste. It also specifies how packaging trash and wastepaper should be handled.

Sweden's management of waste and sector are highly developed. This provides a strong basis for addressing the issues of increasing resource efficiency while satisfying future EU regulation needs. It does, however, provide a difficulty in that major change is necessary, and existing procedures and infrastructure have the ability to stymie progress.

If better recycling rates are to be attained, it becomes evident that the ongoing trend of more separate door-to-door collection from residences must continue. The division of responsibilities between municipalities (responsible for collecting mixed residual trash and separate biowaste) and producer responsibility organizations (PROs, responsible for collecting packaging and paper) may be a dilemma. Because the entire economics of a recycling-led system (collecting cost, sorting cost, income from sale of secondary materials, contributions from producers, avoided disposal costs) are shared between the two different systems, there may be a lack of integration of collection systems. PROs understandably want to focus their attention on lower-cost collection techniques like as bring systems in order to keep compliance expenses for their members low. Furthermore, the low cost of mixed residual waste disposal in Sweden does not give the same economic incentive to separate and recycle items as it does in many other EU Member States (Eurostat).

The implementation of door-to-door separate collection for a wide range of recyclables is anticipated to necessitate a stronger integration of municipal and producer activities. In Sweden, there are many examples of high-performing door-to-door collections, particularly in the country's south, but there are also many examples of low-performing systems, with municipalities relying heavily on producer-funded networks of bring banks for separate collection of many dry fractions. There is a wide range of collection methods across the nation, and there are currently insufficient incentives to encourage municipalities to implement full door-to-door collection or producers to join in funding and operating these upgraded services. In any case, reform of the producer responsibility system for packaging is likely to be required in the near future in order to comply with changes in requirements at the EU level, and this may present an opportunity to align the economic interests of municipalities and producers in order to achieve a more integrated system. What is apparent is that future objectives will not be attained unless door-to-door collection methods are significantly expanded.

In terms of incineration, Sweden's capacity in 2017 was 591 kg per person (6.6 M tonnes total), which is fairly high by EU standards (Statistics Sweden). This level of incineration capacity is incompatible with meeting the WFD's recycling objectives, since it relies on imported garbage to sustain incinerator capacity as more Swedish waste is diverted for material recycling. However, due to their interaction with well-established district heating networks, Swedish incineration facilities are among the most efficient in the world. Importing refuse-derived fuel from other European nations can assist to minimize overcapacity in other countries while also supporting the Swedish sector as the country transitions to a more recycling-focused approach. Various tactics, such as fees, restrictions, and collecting and sorting requirements, to mention a few, might be used to drive this transition.

The long-term objective is a circular economy in which waste is avoided in principle and resources are kept in societal circulation or restored to nature's own cycle in a sustainable manner. Products should be built to be long-lasting and repairable, with the ability to reuse and, eventually, recycle materials. Hazardous compounds, in particular, should be phased out of the circuit. Consider design guidelines that aim to avoid the presence of hazardous compounds in new goods as a good starting point for Swedish work. By being successful in shifting to a circular economy, new technologies, creative goods and services, sustainable and resource-efficient business strategies, and consumer behaviours are required. To accomplish this, a variety of instruments and activities, as well as collaboration among various actors and sectors, are required. To far, the Swedish Government has offered a variety of initiatives for Sweden, as well as executed or carried out a number of studies critical to the transition to a circular economy.

4.1.2 Circular economy and sustainability in Sweden

Sweden and many other European nations have successfully integrated green political parties into their political structures and decision-making processes, which has promoted and expedited the transition to CE. Sweden has also developed several incentive schemes in the past to provide ideal circumstances for a steady and successful increase in recycling rates through public education and involvement. The economic system, as well as process and product improvements, have lowered material usage and made substitutes available. However, repeating behaviour materials have not progressed sufficiently to catch up with CE recycling and components of reduction. A circular economy is often seen as a development model that alleviates conflicts between environmental concerns and economic progress. CE can also aid in the consideration of pollution issues and resource shortages, as well as green competitiveness.

According to the Swedish government"s office"s report, "Sweden’s national strategy for sustainable development, " (GO, 2002) is described as the overarching goal of the government"s policy. Sweden's national sustainable development (GO, 2002) plan is a complicated approach that aims to integrate economic, social, cultural, and environmental concerns in order to achieve more sustainable development. The Swedish government established the Delegation for a Circular Economy in 2018 with the goal of bolstering Swedish society's national and regional transition to a resource-efficient, circular, and bio-based economy. Initially, the Delegation concentrated on three areas: circular design, plastic materials, and public procurements. By selecting a circularity design, the Delegation hoped to contribute to new business models in which circularity was included into the design of both outputs and manufacturing processes. Plastic is a common material that has a high potential for greater recycling and material life. Every year, public procurement creates enormous volumes of products and services in a welfare society with a substantial public sector, such as Sweden. As a result, procurement has a significant influence on resource flows, which the Delegation believes may be oriented toward higher reuse and longer material life. The main tasks of the Swedish Delegation for Circular Economy are as follows: developing a strategy for a shift to a bio-based and circular economy at various levels of society; contacting relevant actors for inclusive participation; identifying barriers, needs for education, and advising and proposing cost-effective measures to the government; gathering and sharing knowledge about ongoing initiatives and facilitating collaboration between them; and designating reference groups. establishing an innovative, competitive, and sustainable business environment at the national and regional levels; and establishing a transition process that can contribute to national environmental goals, strengthen Sweden's competitiveness, and increase its contribution to the integration of the United Nations Sustainable Development Agenda 2030.

Points of departure for strategy formulation

The starting points for the undertaking of developing a national strategy should:

- contain all three components of sustainability, according to the strategy (environmental, social, and economic),
- address all pertinent aspects of Swedish policy and should be founded on current government policy,
- engage with and coordinate with appropriate parties international policies,
- emphasize the connections between diverse policy areas, as well as discover synergies,
- promote societal awareness of the issue spark a broad discourse, and
- be a live document that is reviewed on a regular basis as well as revised

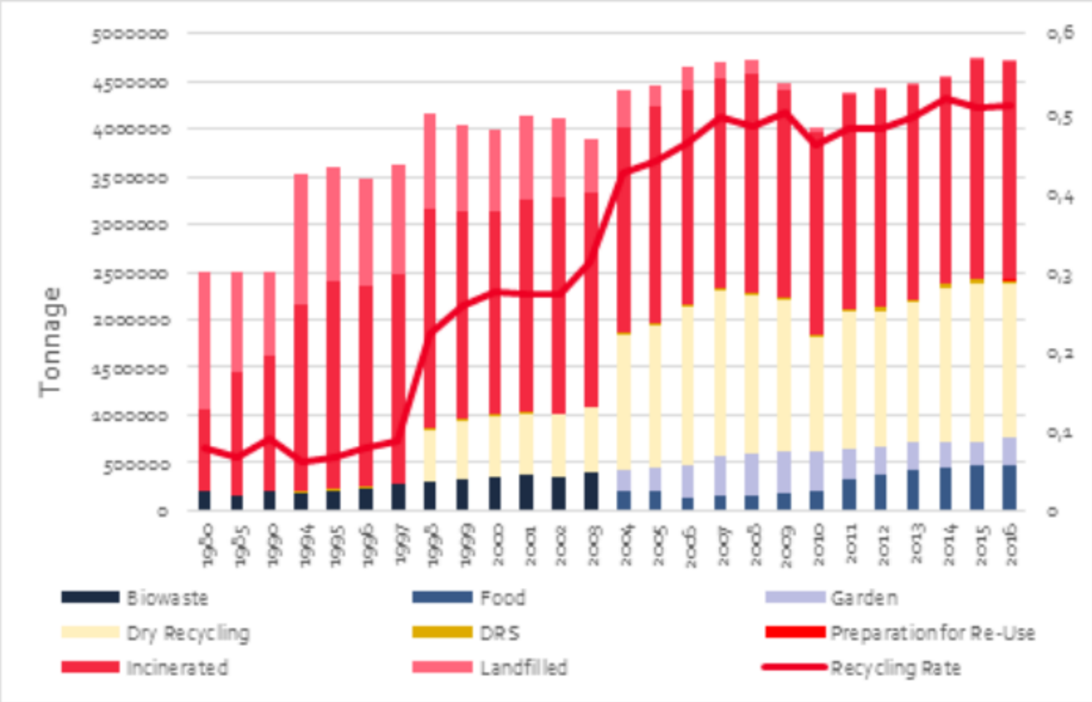
4.2 Waste recycling organization in Sweden

In Sweden, municipal waste is currently defined as being similar to household waste. According to the Swedish Environmental Code, domestic waste includes garbage from homes and analogous waste from other activities. Waste equivalent to domestic waste, which is waste generated when land or houses is used for residential purposes. In Sweden, no earlier definitions of municipal garbage have been used.

The quantity of garbage collected for recycling is considered as recycling. Sweden recorded a municipal garbage recycling rate of 48.9 percent in 2016 and has achieved a recycling percentage in the upper 40s since 2006 (Avfall Sverige). However, the claimed recycling percentage has been stable since 2008, ranging around 45–50 percent (Avfall Sverige). This might be attributable to the fact that policies have not significantly changed during the timeframe, however, there has been talk about producer responsibility and how to modify it.

In addition, there has been minimal political change since 2008. As Swedish politics enters a moment of transition, waste policies may be revised in the near future. It is also worth noting that Sweden's claimed recycling rate for some items may be significantly greater than the actual recycling rate. According to recent data, the number of plastics recycled from those collected might be as low as 20–25 percent, with the remainder burnt in waste-to-energy plants (Zero waste EU, 2018). This problem also affects Iceland, which exports plastic garbage to Sweden.

Figure 8: Waste recycling in Sweden



Source: Eurostat

The figure 8 represents the treatment path of household garbage in Sweden, displaying the tonnage processed under each technique and the consequent recycling rate. Since the implementation of landfill waste laws in 2001, the amount of landfill has reduced. More cities are collecting organic waste as a separate waste portion, which has increased collection and recycling. Concurrently, biogas output in Sweden has expanded. Dry recycling collections in Sweden have consistently grown throughout the time depicted, with both the number of houses served and the variety of recyclables collected growing. Biowaste has been described as two distinct component parts since 2004: food waste and garden waste. The overall volume of garbage and the recycling rate have both grown in recent years (Statistics Sweden).

4.2.1 Approach to Waste Collections

Citizens, or households, are the first and most important link in the existing waste management system. In accordance with the current legislation, any waste is subject to mandatory delivery to reception points in sorted form, for example, separately wastepaper, plastic packaging, paper packaging, electrical waste, batteries, metal packaging, white and coloured glass containers, bulky waste, etc. To dispose of waste independently – to hand them over in an unsorted form, or to throw them away in the wrong places - at home farms have no right. The exception is gardening waste, which households have the opportunity to dispose of on their plots at their discretion. Household waste that cannot be sorted is treated as fuel. The sorted waste is subject to delivery to points and stations of separate reception and processing of household waste.

4.2.2 Disposal of household waste.

Hazardous household waste. In 2017, 76,980 tons of hazardous household waste, or 7.6 kg per inhabitant, were collected in the country. These volumes include 50.4 thousand tons of infected forest and 3.16 thousand tons of asbestos. In addition, 23.4 thousand tons of paints, chemicals and residues of petroleum products were disposed of as hazardous waste (Stena Recycling). After entering the receiving stations, household waste belonging to the category of hazardous is first processed, then disposed of using special technologies (to exclude hazardous components from circulation, for example, mercury). Substances that cannot be neutralized or reused are subject to burial. Toxic substances (for example, chemicals) are burned in special furnaces at high temperature. Polluted land is cleaned through biological decomposition. The wood impregnated with chemicals is sawn into sawdust and burned to generate energy at plants that have a special permit for burning such products.

Electronic scrap and batteries. In 2017, 127,800 tons of electric batteries and other waste from electronic devices were collected in the country, an average of 12.6 kg per person. Including, 13,250 tons of household batteries, built-in and replaceable, as well as 6,610 tons of car batteries. In each commune there are specialized reception points for household batteries and light sources, usually located in shopping malls (Stena Recycling,2018).

Biological processing. More than 15% of household waste is subjected to biological processing. Specialized points for the collection of food waste are available in 223 of the 290 communes of the country. In 2017, the volume of collected food waste amounted to 2.214million tons, or 219 kg per person (Stena Recycling).

The importance of biological waste treatment in Sweden's waste management system is growing all the time. Biological processing is mostly affected by food waste. When these wastes decay, biogas is produced, which mostly consists primarily of methane and carbon dioxide. Biomass is a renewable source that may be utilized to create thermal energy or as an ecologically acceptable car fuel.

In addition to biogas, biological fertilizer is formed during rotting, which can then be used for agricultural needs. Part of the biological waste is composted, then the compost is used to produce fertilizers. Own plants for composting food waste with a total annual capacity of 20.41 thousand tons per year. Nutritional waste processing facilities based on sewage systems with an annual capacity of 54.12 thousand tons (Stena Recycling).

4.2.3 Landfills for waste disposal

As a result of an active policy to encourage the use of waste as secondary raw materials and for energy generation, the number of landfills has decreased following a reduction in the volume of disposal. In 2017, the communes owned only 36 active landfills. They received 23.65 thousand tons of household waste (approx. 2 kg per inhabitant or 0.5% of the total volume of household waste), moreover 2,117.3 thousand tons of industrial waste. (Stena Recycling). About 30 more landfills are operated by production companies within the framework of existing technological cycles. In turn, 31 landfills have been mothballed. (Stena Recycling).

Nevertheless, the preserved landfills continue to be maintained, mainly for the purpose of removing infiltration and accumulating gas. Only those wastes – domestic or industrial – that cannot be recycled, used as fuel or burned are subject to burial at landfills. Preliminary sorting is carried out at all landfills in order to separate materials suitable for reuse or incineration.

As a consequence, less than half of the waste coming to landfills is buried, the rest after separation is sent for reuse, recycling and energy recovery. In addition, ash and ashes formed as a result of waste incineration for energy generation, as well as contaminated soils, etc., are brought to landfills. Landfills are also used as intermediate waste storage sites by other manufacturers, for example, paper or glass manufacturers.

4.3 Econometric analysis

Data for the period 2000-2019 were collected from the World Bank and Eurostat. The variables are GDP growth (annual %), logarithm, and import of goods and services (annual %), and total recycling rate of municipal waste (percent out of 100%).

The economic way of the model is given algebraically as follows:

$$Y_1t=f\,(X_1t,\ X_2t) \tag{4}$$

The model consists of variables where:

Y_{1t}...LN Gross Domestic Product of Sweden annual percents

X_{1t}...Municipal recycling waste percents

X_{2t}...LN Import of goods and services annual percents

Table 4: Data

Year	GDP growth (Annual %)	Total recycling rate of municipal waste (%, out of 100%)	Import of goods and services (annual %)
Variable	**y**	**X1**	**X2**
2000	26.29479	38.5	25.33296
2001	26.21384	39	25.23747
2002	26.30995	39.7	25.28751
2003	26.53542	41.3	25.4833
2004	26.67682	43.9	25.6524
2005	26.69508	44.6	25.74668
2006	26.77086	47.7	25.87211
2007	26.92022	46.7	26.042

2008	26.97267	45.6	26.13974
2009	26.80214	49.2	25.836
2010	26.92946	47.8	26.00235
2011	27.07606	47	26.17268
2012	27.03769	46.9	26.12775
2013	27.09802	48.2	26.13801
2014	27.08967	49.3	26.16503
2015	26.94803	47.5	26.03066
2016	26.9687	48.4	26.0431
2017	27.01672	46.8	26.12999
2018	27.04305	45.8	26.20945
2019	27.00344	46.6	26.17389

Source: Eurostat

An OLS regression will be used to analyse the data gathered and reported in (Table 4).

4.3.1 Regression model

The following result was derived using the OLS regression of the Recycling rate of municipal waste (Re), LN_IMPGS, and LN_GDP growth.

Figure 9: Regression model

```
Model 2: OLS, using observations 2000-2019 (T = 20)
Dependent variable: LNGDP

             coefficient   std. error   t-ratio    p-value
  ---------------------------------------------------------
  const       6.99427      1.20202       5.819    2.05e-05  ***
  Re          0.0122789    0.00526657    2.331    0.0323    **
  LNIMP       0.744148     0.0542884    13.71     1.28e-010 ***

Mean dependent var   26.82013   S.D. dependent var   0.280241
Sum squared resid    0.023842   S.E. of regression   0.037450
R-squared            0.984022   Adjusted R-squared   0.982142
F(2, 17)             523.4703   P-value(F)           5.37e-16
Log-likelihood       38.94145   Akaike criterion    -71.88291
Schwarz criterion   -68.89571   Hannan-Quinn        -71.29978
rho                  0.560128   Durbin-Watson        0.864376
```

Source: GRETL

Based on the calculations in GRETL, a screenshot of which can be seen above, we can note that the formulation of the model stochastic is as follows:

LNGDPt = 6.994+ 0.012 x1t+ 0.744x2t + µt

A series of tests for the verification of the Linear Regression Model were performed based on the findings of the OLS regression.

4.3.2 Economic verification

To determine the quality of the estimated econometric model, model validation is required. Economic (logical) verification is just one of these verifications, in which we verify the direction and intensity of the explanatory variables on the variable explained.

In the framework of the economic verification, will be performed the individual interpretation of the parameters and the verification itself, including the evaluation. The table shows the interpretation of the parameters and their economic commentary.

Parameter	*Value*	*Interpretation*	*A commnet*
γ_1	6.994	-	It conforms to economic verification
γ_2	0.012	If the municipal recycling waste increases by 1 annual %, then the GDP growth will be increased by 0.0012 %	It conforms to economic verification
γ_3	0.744	If import of goods and services increases by 1 annual %, then the GDP growth will be increased by 0.744 %	It conforms to economic verification

4.3.3 Statistical verification

Statistical verification is another verification verifying the linear regression model. This is used to determine whether the estimated parameters are statistically significant.

The coefficient of determination (R2) in basic regression analysis quantifies the proportion of the variation in the dependent variable explained by the independent variable. According to our model, the determination coefficient determines that changes in the explanatory variables explain 98.4 percent of the variations in the explained variable in the model.

Statistical significance of the estimated parameters

For testing the statistical significance of the estimated parameters can be used the t-test. The significance level is chosen at 5%. Test criteria are compared with tabular values for significance level and degrees of freedom. These are equal to T - K - 1 = 20 - 3. The number of degrees of freedom is 17 i.e., a critical value of **2.10982**.

	LNGDP	**Re**	**LNIMP**
t-ratio	**5.819**	**2.331**	**13.71**
t-value	**2.10982**	**2.10982**	**2.10982**
a	**0.05**	**0.05**	**0.05**
S / N	**N**	**S**	**N**

Source: GRETL

S= parameter statistically significant, N= parameter statistically not significant

The table above shows that the first, parameter is significant and, on the other hand, the second and third parameters, which are the export and recycling waste are insignificant.

4.3.4 Autocorrelation test

Autocorrelation means that residues are correlated with their delayed values. As a result, the estimate is not the best, so it will be inadequate. It is tested using the test:

Breusch-Godfrey's first-order autocorrelation test

H_0: no autocorrelation of residues (p-value> $\alpha = 0.05$)

H_1: is autocorrelation of residues

Figure 10: Autocorrelation test

```
Breusch-Godfrey test for first-order autocorrelation
OLS, using observations 2000-2019 (T = 20)
Dependent variable: uhat

             coefficient    std. error   t-ratio    p-value
  ---------------------------------------------------------
  const       0.0105149     1.03805       0.01013   0.9920
  Re         -0.000808527   0.00455866   -0.1774    0.8615
  LNIMP       0.000971095   0.0468838     0.02071   0.9837
  uhat_1      0.571084      0.219077      2.607     0.0191   **

  Unadjusted R-squared = 0.298099

Test statistic: LMF = 6.795252,
with p-value = P(F(1,16) > 6.79525) = 0.0191

Alternative statistic: TR^2 = 5.961989,
with p-value = P(Chi-square(1) > 5.96199) = 0.0146

Ljung-Box Q' = 6.30989,
with p-value = P(Chi-square(1) > 6.30989) = 0.012
```

Source: GRETL

The above result of the Breusch-Godfrey test for first-order autocorrelation shows that Alternative statistics: TR ^ 2 = 5.961989, with p-value = 0.0146

0.0146 < 0.05 do rejection H_1: is autocorrelation of residues present

In regression analysis, there is the autocorrelation of regression residuals can occur as consequence of the model does not agree well with the data. That happened due to the dependent variable is affected by factors not accounted for in the model. Since the time series is autocorrelated in the analysis, the more strongly its observations are connected. The Durbin-Watson criterion is used to detect autocorrelation in time series.

Durbin-Watson statistic = 0.864376, p-value = 0.000650346

The Durbin- Watson statistic shows that the value is equal to 0.864376 meaning there is a positive autocorrelation

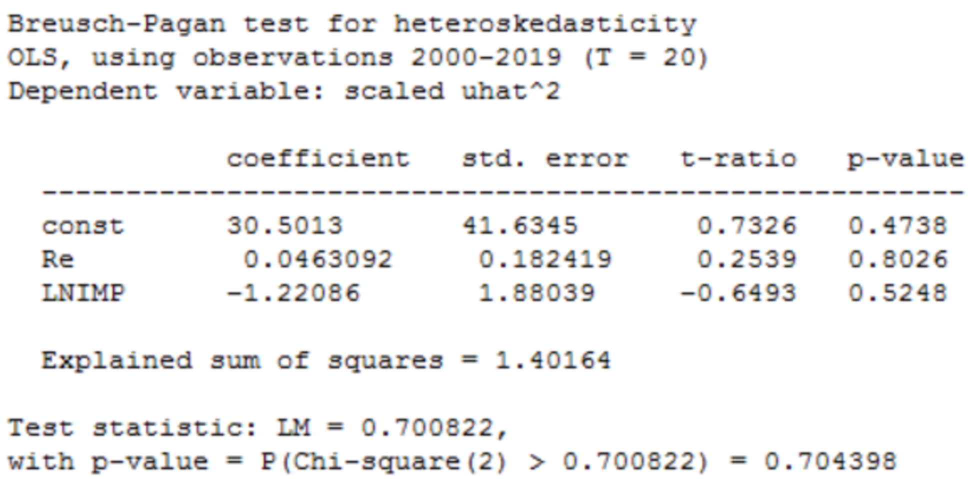
4.3.5 Heteroskedasticity test

Detection was performed by the test: *Breusch-Pagan test for heteroskedasticity*

H_0: homoskedasticity, dispersion of the random component is final and constant over time

H_1: heteroskedasticity of the random component

Figure 11:Heteroskedasticity test



```
Breusch-Pagan test for heteroskedasticity
OLS, using observations 2000-2019 (T = 20)
Dependent variable: scaled uhat^2

             coefficient   std. error   t-ratio   p-value
  --------------------------------------------------------
  const      30.5013       41.6345       0.7326   0.4738
  Re          0.0463092     0.182419     0.2539   0.8026
  LNIMP      -1.22086       1.88039     -0.6493   0.5248

  Explained sum of squares = 1.40164

Test statistic: LM = 0.700822,
with p-value = P(Chi-square(2) > 0.700822) = 0.704398
```

Source: GRETL

According to the Breusch-Pagan test shows value = 0.704398 > 0.05, therefore the null hypothesis is not rejected, and no heteroscedasticity in the model.

4.3.6 Normality test

Zero hypothesis test of normal distribution:

H_0: Random component has a normal distribution (p-value> $\alpha = 0.05$)

H_1: Random component does not have a normal distribution

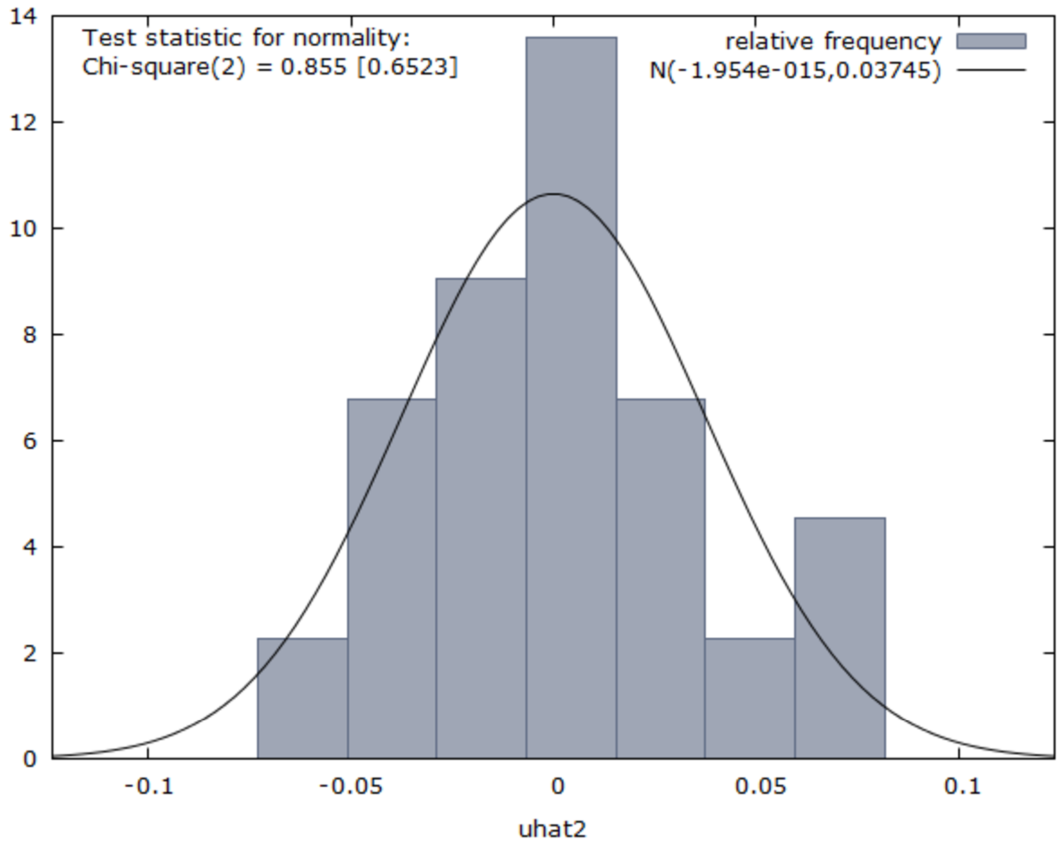
Figure 12: Normality test

```
Frequency distribution for uhat2, obs 1-20
number of bins = 7, mean = -1.95399e-015, sd = 0.0374499

       interval          midpt   frequency    rel.     cum.

            < -0.050771  -0.061811      1      5.00%    5.00% *
  -0.050771 - -0.028692  -0.039731      3     15.00%   20.00% *****
  -0.028692 - -0.0066128 -0.017652      4     20.00%   40.00% *******
 -0.0066128 -  0.015466   0.0044268     6     30.00%   70.00% **********
   0.015466 -  0.037545   0.026506      3     15.00%   85.00% *****
   0.037545 -  0.059625   0.048585      1      5.00%   90.00% *
           >=  0.059625   0.070664      2     10.00%  100.00% ***

Test for null hypothesis of normal distribution:
Chi-square(2) = 0.855 with p-value 0.65226
```

Source: GRETL

As the result of the Normality test shows the p-value = 0.65226 > 0.05, therefore the null hypothesis the residues have a normal distribution.

Figure 13: Normality test graph



Source: GRETL

4.3.7 R-squared

R- squared measure goodness of fit. The coefficient of determination R^2 = 0.984022, this means about 98.40% of the variation in the LNGDP growth (y) can be explained by the LN_ IMP and Re. A higher R^2 indicated a better fit for the model.

4.3.8 Statistical results and interpretation of the first model

Based on the statistical validation of this regression, we can infer that there is no, heteroskedasticity, random variable normality, and the significance of calculated coefficients, however there is an autocorrelation, and Durbin Watson test used for estimation weather it is positive or negative autocorrelation. Based on the results of those tests and observations, the OLS coefficient estimate is BLUE (Best Linear Unbiased Estimate). In this investigation, the ordinary least squares (OLS) regression gave unbiased results with the lowest variance of all feasible linear estimators. The OLS regression yielded the following equation: LN_GDP growth = 6.99427 -+ 0.0122789 Re + 0.744148 LNIMP + et. It can be deduced that a one-point rise in the year-to-year value of LN IMP results in a 0.7 percent drop in the year-to-year value of the GDP growth. An increase of one in the year-to-year value of Re results in a 0.7 percent rise in the year-to-year value of the GDP growth.

4.4 Econometric analysis part 2

Data for the period 2000-2019 were collected from the World Bank and Eurostat. The variables are LNGDP growth (annual percent), logarithm, and Export of goods and services (annual percent), and total recycling rate of municipal waste (percent out of 100%).

The economic way of the model is given algebraically as follows:

$$Y_1t=f\,(X_1t,\ X_2t) \qquad (5)$$

The model consists of variables where:

Y_{1t}...LN Gross Domestic Product of Sweden annual percents

X_{1t}...Municipal recycling waste percents

X_{2t}...LN Export of goods and services annual percents

Table 5: Data 2

Year	GDP growth (annual %)	Total recycling rate of municipal waste (% out of 100%)	Export of goods and services (annual %)
Variable	**y**	**X1**	**X2**
2000	26.29479	38.5	25.45681662
2001	26.21384	39	25.36802307
2002	26.30995	39.7	25.42435941
2003	26.53542	41.3	25.62723486
2004	26.67682	43.9	25.8256253
2005	26.69508	44.6	25.89692013
2006	26.77086	47.7	26.02615381
2007	26.92022	46.7	26.17810238
2008	26.97267	45.6	26.26109612
2009	26.80214	49.2	25.96867124
2010	26.92946	47.8	26.1237939
2011	27.07606	47	26.28355987
2012	27.03769	46.9	26.23979361
2013	27.09802	48.2	26.24298565

2014	27.08967	49.3	26.2518751
2015	26.94803	47.5	26.12173436
2016	26.9687	48.4	26.11753228
2017	27.01672	46.8	26.18969193
2018	27.04305	45.8	26.2596115
2019	27.00344	46.6	26.26548418

Source: Eurostat

An OLS regression will be used to analyse the data gathered and reported in (Table 5)

4.4.1 Regression model

The following result was derived using the OLS regression of the Recycling rate of municipal waste (Re), LN_EXPGS, and LN_GDP growth.

Figure 14:Regression model 2

```
Model 2: OLS, using observations 2000-2019 (T = 20)
Dependent variable: LNGDP

             coefficient   std. error   t-ratio    p-value
  ---------------------------------------------------------
  const      5.20212       1.48888       3.494     0.0028    ***
  LNEXP      0.815100      0.0664630    12.26      7.21e-010 ***
  Re         0.00922889    0.00609101    1.515     0.1481

Mean dependent var    26.82013   S.D. dependent var    0.280241
Sum squared resid     0.029181   S.E. of regression    0.041431
R-squared             0.980444   Adjusted R-squared    0.978143
F(2, 17)              426.1432   P-value(F)            2.99e-15
Log-likelihood        36.92083   Akaike criterion     -67.84167
Schwarz criterion    -64.85447   Hannan-Quinn         -67.25854
rho                   0.638441   Durbin-Watson         0.731290
```

Source: GRETL

Based on the calculations in GRETL, a screenshot of which can be seen above, we can note that the formulation of the model stochastic is as follows:

LNGDPt = 5.202+ 0.815 x1t+ 0.009x2t + μt

A series of tests for the verification of the Linear Regression Model were performed based on the findings of the OLS regression.

4.4.2 Economic verification

To determine the quality of the estimated econometric model, model validation is required. Economic (logical) verification is just one of these verifications, in which we verify the direction and intensity of the explanatory variables on the variable explained.

Parameter	*Value*	*Interpretation*	*A commnet*
γ_1	5.202	-	It conforms to economic verification
γ_2	0.815	If expot of goods and services increases by 1 annual %, then the GDP growth will be increased by 0.815 %	It conforms to economic verification
γ_3	0.009	If the municipal recycling waste increases by 1 annual %, then the GDP growth will be increased by 0.009 %	It conforms to economic verification

In the framework of the economic verification, will be performed the individual interpretation of the parameters and the verification itself, including the evaluation. The table shows the interpretation of the parameters and their economic commentary

4.4.3 Statistical verification

Statistical verification is another verification verifying the linear regression model. This is used to determine whether the estimated parameters are statistically significant.

The coefficient of determination (R2) in basic regression analysis quantifies the proportion of the variation in the dependent variable explained by the independent variable. According to our model, the determination coefficient determines that changes in the explanatory variables explain 98.04 percent of the variations in the explained variable in the model

Statistical significance of the estimated parameters

For testing the statistical significance of the estimated parameters can be used the t-test. The significance level is chosen at 5%. Test criteria are compared with tabular values for significance level and degrees of freedom. These are equal to T - K - 1 = 20 - 3. The number of degrees of freedom is 17 i.e., a critical value of **2.10982**.

	LNGDP	**LNEXP**	**Re**
t-ratio	**3.494**	**12.26**	**1.515**
t-value	**2.10982**	**2.10982**	**2.10982**
a	**0.05**	**0.05**	**0.05**
S / N	**S**	**N**	**N**

Source: GRETL

S= parameter statistically significant, N= parameter statistically not significant

The table above shows that the first, parameter is significant and, on the other hand, the second and third parameters, which are the export and recycling waste are insignificant.

4.4.4 Autocorrelation test

Autocorrelation means that residues are correlated with their delayed values. As a result, the estimate is not the best, so it will be inadequate. It is tested using the test:

Breusch-Godfrey's first-order autocorrelation test

H_0: no autocorrelation of residues (p-value> $\alpha = 0.05$)

H_1: is autocorrelation of residues

Figure 15:Autocorrelation test 2

```
Breusch-Godfrey test for first-order autocorrelation
OLS, using observations 2000-2019 (T = 20)
Dependent variable: uhat

             coefficient   std. error   t-ratio   p-value
  --------------------------------------------------------
  const       0.462691     1.20278       0.3847   0.7055
  LNEXP      -0.0203148    0.0536793    -0.3784   0.7101
  Re          0.00141460   0.00490514    0.2884   0.7767
  uhat_1      0.649638     0.201209      3.229    0.0053  ***

  Unadjusted R-squared = 0.394497

Test statistic: LMF = 10.424327,
with p-value = P(F(1,16) > 10.4243) = 0.00525

Alternative statistic: TR^2 = 7.889947,
with p-value = P(Chi-square(1) > 7.88995) = 0.00497

Ljung-Box Q' = 8.53974,
with p-value = P(Chi-square(1) > 8.53974) = 0.00347
```

Source: GRETL

The above result of the Breusch-Godfrey test for first-order autocorrelation shows that Alternative statistics: TR ^ 2 = 7.88995, with p-value = 0.00497

0.00497< 0.05 do rejection H_1: is autocorrelation of residues present

In regression analysis, there is the autocorrelation of regression residuals can occur as consequence of the model does not agree well with the data. That happened due to the dependent variable is affected by factors not accounted for in the model. Since the time series is autocorrelated in the analysis, the more strongly its observations are connected. The Durbin-Watson criterion is used to detect autocorrelation in time series.

Durbin-Watson statistic = 0.73129, p-value = 0.00017081

The Durbin- Watson statistic shows that the value is equal to 0.73129 meaning there is a positive autocorrelation.

4.4.5 Heteroskedasticity test

Detection was performed by the test: *Breusch-Pegan test for heteroskedasticity*

H_0: homoskedasticity, dispersion of the random component is final and constant over time

H_1: heteroskedasticity of the random component

Figure 16:Heteroskedasticity test 2

```
Breusch-Pagan test for heteroskedasticity
OLS, using observations 2000-2019 (T = 20)
Dependent variable: scaled uhat^2

             coefficient   std. error   t-ratio   p-value
  -------------------------------------------------------
  const      10.2185       47.2010       0.2165   0.8312
  LNEXP      -0.523914      2.10704     -0.2486   0.8066
  Re          0.0967969     0.193100     0.5013   0.6226

  Explained sum of squares = 0.733911

Test statistic: LM = 0.366955,
with p-value = P(Chi-square(2) > 0.366955) = 0.832370
```

Source: GRETL

According to the Breusch-Pagan test shows value = 0.832370 > 0.05, therefore the null hypothesis is not rejected, and no heteroscedasticity in the model.

4.4.6 Normality test

Zero hypothesis test of normal distribution:

H_0: Random component has a normal distribution (p-value> $\alpha = 0.05$)

H_1: Random component does not have a normal distribution

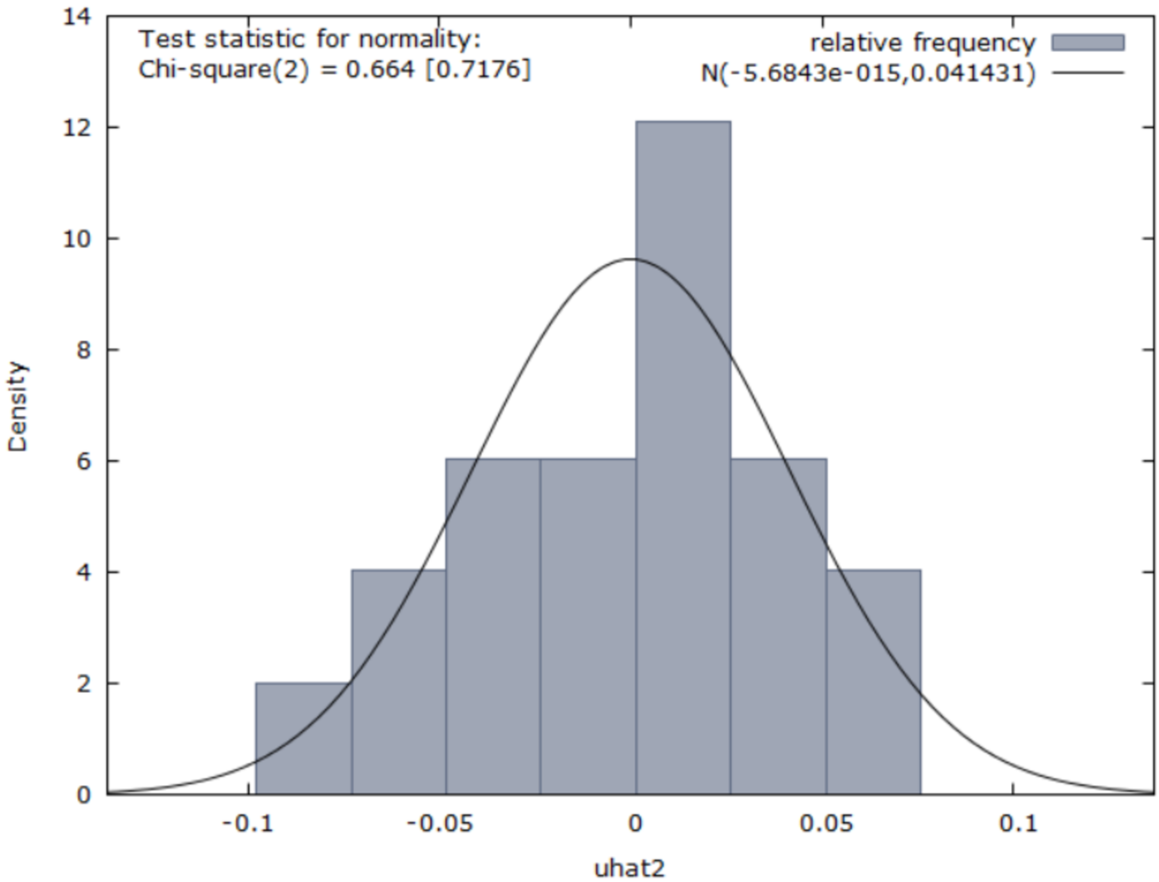
Figure 17:Normality test 2

```
Frequency distribution for uhat2, obs 1-20
number of bins = 7, mean = -5.68434e-015, sd = 0.0414312

       interval          midpt   frequency    rel.     cum.

            < -0.073006 -0.085404      1      5.00%    5.00% *
 -0.073006 - -0.048209 -0.060607      2     10.00%   15.00% ***
 -0.048209 - -0.023412 -0.035810      3     15.00%   30.00% *****
 -0.023412 -  0.0013848-0.011014      3     15.00%   45.00% *****
 0.0013848 -  0.026182  0.013783      6     30.00%   75.00% **********
  0.026182 -  0.050978  0.038580      3     15.00%   90.00% *****
           >=  0.050978  0.063377      2     10.00%  100.00% ***

Test for null hypothesis of normal distribution:
Chi-square(2) = 0.664 with p-value 0.71761
```

Source: GRETL

As the result of the Normality test shows the p-value = 0.71761 > 0.05, therefore the null hypothesis the residues have a normal distribution.

Figure 18: Normality test graph 2



Source: GRETL

4.4.7 R-squared

R-squared measure goodness of fit. The coefficient of determination $R^2 = 0.980444$, this means about 98.04% of the variation in the GDP growth (y) can be explained by the LN_ EXP and Re. A higher R^2 indicated a better fit for the model.

4.4.8 Statistical results and interpretation of the second model

Based on the statistical validation of this regression, we can infer that there is no, heteroskedasticity, random variable normality, and the significance of calculated coefficients, however there is an autocorrelation, and Durbin Watson test used for estimation weather it is positive or negative autocorrelation. Based on the results of those tests and observations, the OLS coefficient estimate is BLUE (Best Linear Unbiased Estimate). In this investigation, the ordinary least squares (OLS) regression gave unbiased results with the lowest variance of all feasible linear estimators. The OLS regression yielded the following equation: GDP growth = 5.20212 -+ 0.815100 LN EXP + 0.00922889 Re + et. It can be deduced that a one-point rise in the year-to-year value of LN EXP results in a 0.8 percent drop in the year-to-year value of the GDP growth. An increase of one in the year-to-year value of Re results in a 0.009 percent rise in the year-to-year value of the GDP growth.

5 Results and Discussion

The circular economic well-being of a country, additionally distribution and export and import of goods and services, can be measured using the GDP, waste management, which shows how well the circular economy is performing and how well it will perform in the future, levels of waste recycling, and the country's different sectors outcome are essential economic performance indicators because they show whether an economy is growing or collapsing. In this research, GDP and the import and export of goods and services were selected as economic performance indicators to evaluate the country's sustainable growth, and the influence of recycling garbage on both GDP and the rate of export and import in Sweden.

The practical part econometric analysis was based on GDP growth, export and import of goods and services and recycling municipalities waste in Sweden observed during the period 2000–19. The analysis demonstrates how the overall environmental and circular economy circumstances have changed in recent years.
Both models were estimated using the OLS technique, which aided in determining the association between variables. Economic verification enabled the quantification of the link between GDP growth and selected macroeconomic parameters. Statistical validation assessed the model's overall relevance as well as the significance of individual predicted parameters. The autocorrelation test, heteroskedasticity test, and residual normality test were used to provide econometrical validation. Despite the fact that both estimates were found to be statistical significance, nevertheless the data indicates that there are substantial disparities between Swedish recycling municipalities waste in CE and GDP development.

In the first investigation, the ordinary least squares (OLS) regression gave unbiased results with the lowest variance of all feasible linear estimators. The following equation resulted from the OLS regression: GDP expansion = 6.99427 -+ 0.0122789 Re + 0.744148 LNIMP + et A one-point increase in the year-to-year value of LN IMP leads in a 0.7 percent increase in the year-to-year value of GDP growth. A one-point increase in the year-to-year value of Re translates in a 0.7-point decrease in the year-to-year value of GDP growth.

A 1% rise in the value of import goods and services year over year corresponds to a 0.74 percent increase in the value of GDP growth year over year.

In the second investigation, the ordinary least squares (OLS) regression gave unbiased results with the lowest variance of all feasible linear estimators. The following equation resulted from the OLS regression: GDP expansion = 5.20212 -+ 0.815100 LN EXP + 0.00922889 Re + et A one-point increase in the year-to-year value of LN EXP translates in a 0.8 percent decline in the year-to-year value of GDP growth. A one-point increase in the year-to-year value of Re leads in a 0.009% increase in the year-to-year value of GDP growth. It may be deduced that a one-point rise in the year-to-year value of LN EXP leads to a 0.8-point increase in the year-to-year value of GDP. An increase of one in the year-to-year value of RE results in a 0.009 percent rise in the year-to-year value of GDP growth.

6 Conclusion

The circular economy is growing in popularity among policymakers, corporations, and academics. For example, the European Union (EU) and some governments, notably those in Finland, the Netherlands, and Sweden, support CE as a method of transitioning from a linear "take-make-dispose" economic paradigm to a closed production and consumption system.

Sweden is one of the world leaders in the field of environmentally oriented waste management. An effective independent "ecological" sector has been created in the country’s economy, uniting companies and enterprises of various industries and ensuring, along with solving urgent problems of sustainable development, the creation of high added value through deep processing and generation of energy from waste. The positive results achieved over the past decades have provided Swedish technologies, equipment, and consulting in the field of waste disposal with a leading position in the world.

The study subject examines the adoption of the circular economy idea in Sweden from 2000 to 2019 and how it has affected economic development. The most frequent linear economic model is predicated on the belief that resources are infinite and that waste disposal space is infinite. A paradigm like this is plainly unsustainable, and adjustments must be done. The notion of the circular economy is still poorly understood by all economic players and the general public. Transitioning to a circular economy demands structural changes in industry, social components, energy, transportation, agriculture, and other areas.

As the result of the variables have been obtained the relation of GDP, export and import and recycling waste. Considering that foreign trade is mostly represented by engineering and metal recycling products, cellulose and wood recycling products, metallurgy products, fuel, and chemical products. Sweden provides all the food needs of the population on its own by 85%. Thanks to the domestic companies Vattenfall, Volvo, Bower etc. that helps and support the economic growth. And stay on the first position in the list of the most developed countries in the world. Today, Sweden is considered one of the most economically developed countries in the world.

The advice for future study is to thoroughly investigate the overall region"s circular economy; moreover, cities might be utilized as models of best practices. Despite the fact that scientists confront extra hurdles in research, technology, and infrastructure, individual studies like this one make a little contribution to this modern issue. It is possible to infer that, in addition to investing in the dissemination of information, education, and technology.

7 References

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8 Appendix

Table 6: Data

Year	GDP growth (annual %)	Total recycling rate of municipal waste (% out of 100%)	Import of goods and services (annual %)
Variable	**y**	**X1**	**X2**
2000	26.29479	38.5	25.33296
2001	26.21384	39	25.23747
2002	26.30995	39.7	25.28751
2003	26.53542	41.3	25.4833
2004	26.67682	43.9	25.6524
2005	26.69508	44.6	25.74668
2006	26.77086	47.7	25.87211
2007	26.92022	46.7	26.042
2008	26.97267	45.6	26.13974
2009	26.80214	49.2	25.836
2010	26.92946	47.8	26.00235
2011	27.07606	47	26.17268
2012	27.03769	46.9	26.12775

2013	27.09802	48.2	26.13801
2014	27.08967	49.3	26.16503
2015	26.94803	47.5	26.03066
2016	26.9687	48.4	26.0431
2017	27.01672	46.8	26.12999
2018	27.04305	45.8	26.20945
2019	27.00344	46.6	26.17389

Source: Eurostat

Table 7: Data 2

Year	GDP growth (annual %)	Total recycling rate of municipal waste (% out of 100%))	Export of goods and services (annual %)
Variable	**y**	**x1**	**x2**
2000	26.29479	38.5	25.45681662
2001	26.21384	39	25.36802307
2002	26.30995	39.7	25.42435941
2003	26.53542	41.3	25.62723486
2004	26.67682	43.9	25.8256253
2005	26.69508	44.6	25.89692013
2006	26.77086	47.7	26.02615381
2007	26.92022	46.7	26.17810238
2008	26.97267	45.6	26.26109612
2009	26.80214	49.2	25.96867124
2010	26.92946	47.8	26.1237939
2011	27.07606	47	26.28355987
2012	27.03769	46.9	26.23979361
2013	27.09802	48.2	26.24298565

2014	27.08967	49.3	26.2518751
2015	26.94803	47.5	26.12173436
2016	26.9687	48.4	26.11753228
2017	27.01672	46.8	26.18969193
2018	27.04305	45.8	26.2596115
2019	27.00344	46.6	26.26548418

Source: Eurostat