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Role of Global Trade in the Circular Economy

Daniela ŠÁLKOVÁ* and Aditya Ramanand SINGH

Czech University of Life Sciences Prague, Prague, Czech Republic; salkova@pef.czu.cz; singh@pef.czu.cz
* Corresponding author: salkova@pef.czu.cz

Abstract: Paper examines economic model known as upcycling, which seeks to minimize environmental damage by maximizing the reuse of resources. The use of raw materials, production and consumption that underpin the vertical economic system promoted by global trade has serious social and environmental consequences. The study highlights the opportunities and threats of global exchange in the context of supply chain transformation. Notwithstanding the considerable difficulties, the result suggests that global trade can contribute to the development of a circular economy by increasing productivity, reducing pollution, and encouraging more environmentally responsible production and consumption. The conclusions and suggestions relate to the findings from GRETL and how policy makers, firms and individuals could accelerate the uptake of recycling and reuse in global trade.

Keywords: circular economy; global trade; resources; key challenges; global cooperation

JEL Classification: M31; O13; O44

1. Introduction

The world faces an urgent need to move to a more sustainable economic model that not only promotes economic growth but also reduces environmental impacts and promotes social justice (Geissdoerfer et al., 2017). A linear model of production and consumption (take-make-use-dispose) in which items are produced from raw materials, sold, used, and then disposed through landfilling or trash incineration, has dominated the industrial evolution. The linear model's fundamental presumptions, however, are no longer valid in the current global context, and a number of significant trends are endangering its viability, necessitating the need for an alternative economic model (Vidal-Ayuso et al., 2023). Circular economy is a framework that offers potential solutions for these challenges by promoting a regenerative approach to resource use and waste management (Kirchherr et al., 2023). Separating actual consumption of raw resources from economic growth can achieved through circular economy efforts to close, expand and reduce material loops (Scheel et al., 2020). Methods that could lead to a reduction in the rate of resource extraction and use are part of the system of transition to a circular economy (European Commission, 2019). For greater efficiency, this promotes sustainable management of materials and greater resource efficiency (OECD, 2021). The circular economy started with to reduce the amount of waste produced but has now expanded into a comprehensive strategy to increase the sustainability of resource use (Velenturf & Purnell, 2021). The potential it represents not only for resource savings and improved health and environmental outcomes, but also for business and environmental and financial diversification, is an important element of the attractiveness of the circular economy

(Feng & Goli, 2023). Global supply chains, final value chains and business services are just some of the ways in which circular economy policies and initiatives are linked to global trade (Hofstetter et al., 2021). Economies of scale and new jobs created by trade are two ways in which it can support the functioning of the circular economy (European Commission, 2018).

Private sector needs help in overcoming the barriers to the implementation of circular trading models worldwide (Kirchherr et al., 2017). It is essential to avoid trade that has adverse effects on the environment (Buterbaugh, 2022). More work is needed to be done to ensure that the objectives of trade and the circular economy are compatible (European Parliament, 2023). For example, the transition to a circular economy may have undesirable consequences for supply chains in extractive industries (Castro et al., 2022). However, certain key minerals will always be needed (Azevedo et al., 2022). It is important to guarantee a fair and environmentally sound transformation of the global trade in extractive raw materials (Vela Almeida et al., 2023). The circular economy can also have an impact on trade in goods and services (Barrie & Schröder, 2022). The transition to a circular economy usually involves a greater degree of involvement of the service sector, such as the production of products maintenance, repair and servicing systems, and can create new opportunities for service trade (Reike et al., 2018). The transition to a global circular economy is gradually coming to the attention of political leaders around the world (Ellen MacArthur Foundation & McKinsey & Company, 2014). The purpose of this effort is to promote the circular economy not only within a specific jurisdiction, but also by seeking synergies with other countries in hopes of achieving a material circular economy and ultimately decoupling the circular economy from the resource consumption of the overall economy at the macro level (Di Vaio et al., 2023). Businesses must reduce waste, maximise product life through maintenance and repair, and recycle old parts (Mohammed et al., 2021). Sharing economy and goods-as-a-service business models of this type increase overall efficiency (Curtis, 2021). The analysis showed that supply chain executives want to double their profits from circular products and services by 2030 (Bimpizas-Pinis et al., 2022). In the face of disruption, key corporate representatives are using circular products and business strategies to boost revenue, save costs and build resilience in a low-carbon world. More than half of circular executives surveyed see this economy as critical to future success (Karman, 2022). As more companies implement circular business strategies, society will benefit more (Flores-Tapia et al., 2023). However, most companies still lack a plan to move to a circular business model. This kind of change can be difficult to implement, and success is slow to come (Aarikka-Stenroos et al., 2022). Existing items and processes can be circulated. This could create a suitable framework for a business strategy (Shopova et al., 2023). Buyback programs, repairs, refurbishment, resale, and the use of renewable and recycled materials can extend the life of products (Mallick et al., 2023). The data shows that consumers are ready to switch from buying consumer goods to buying access to products as part of a service, i.e., a package that guarantees reliability, ease, and return (Wang et al., 2020). Businesses that accept circular business models and strategies before it's too late can work with governments to accelerate this shift (Barros et al., 2021).

The main aim of the article is to evaluate the role of global trade in circular economic model to meet the demand of global resources, which is increasing year by year.

2. Methodology

The research uses a systems approach that integrates economic and environmental variables and analyses the role of the circular economy in global trade. The study includes a comparative analysis of different trading regions to provide a global perspective on circular economy practices. We adopt a longitudinal study design and analyze trends over the past decade to assess the evolution of the circular economy in the context of global trade. Our analysis incorporates a multi-sectoral approach and assesses the impacts of circular economy practices in different sectors involved in global trade. Scenario analysis was used to predict the possible future impacts of increased adoption of the circular economy on global trade dynamics. The data validation process ensures the accuracy and reliability of the trade and economic data. The methodology integrates quantitative research, using Eurostat data to discern patterns between global trade and circular economy practices through statistical techniques including regression analysis and correlation matrices. At the same time, it enriches this analysis with a qualitative dimension that explores the differential impacts and practicalities of circular economy initiatives through case studies and interviews with experts. This dual approach not only provides a comprehensive understanding of the role of circular economy in global trade, but also highlights the economic and environmental rationale for its adoption, even in zero waste scenarios. By combining these analytical dimensions, the study offers a nuanced view of the interdependencies between global trade, sustainability and circular economy practices that is consistent with current research and real-world applications. The study explores the implications and assesses how different global trade regulations and policies may affect the uptake of circular economy practices. Finally, a sensitivity analysis was included to test the robustness of our findings to different assumptions and external factors.

Research focuses on a circular economy model that examines the global business practices. For the quantitative analysis, data on global trade and circular economy practices were obtained from Eurostat. The data included statistics on trade volumes, trade flows. The collected data was cleaned and prepared for analysis which included checking for missing values, outliers, and inconsistencies in the data. The data was analyzed using statistical techniques such as regression analysis, ordinary least squares, correlation matrices to identify trends, patterns and relationships between global trade and circular economy practices. Reports and visualizations of the analyzed results were created to help convey the findings and insights. The results of the analysis and lessons learned were synthesized to draw conclusions and make recommendations to strengthen the integration of circular economy principles into global trade practice.

The time series analysis exploited the relationship between the private and public sectors, investment and gross value added in the circular economy sectors and several factors that can influence this relationship. The data covers the period from 2011 to 2020 for trade with the European Union (Table 1). These variables are important because they are all potentially relevant in determining the relationship between private investment and gross value added in circular economy sectors. The per capita production of packaging waste and

the recycling rate of both packaging and municipal waste could reflect the level of concern for the environment and sustainability in the economy. On the other hand, private investment and gross value added in the circular economy sectors promote sustainable practices and have contributed to lower waste production and higher recycling rates. The data were analyzed in GRETL using different statistical methods to understand the relationships between these variables and private investments and gross value added in the circular economy sectors.

Table 1. Data of European Union for analysis in GRETL

Year	Private investment and gross value added related to circular economy sectors (mil. euro)	Generation of packaging waste per capita (kg per capita)	Recycling rate of packaging waste by type of packaging rate (%)	Recycling rate of municipal waste (%)	Generation of municipal waste per capita (kg per capita)
2011	110,100	157	64	38	499
2012	108,900	154	65	40	488
2013	108,800	156	65	41	479
2014	113,100	161	66	43	478
2015	114,900	165	66	44	480
2016	117,700	168	67	45	493
2017	125,700	173	67	46	499
2018	130,800	173	65	46	500
2019	139,100	177	64	47	504
2020	139,100	177	64	49	521

For the qualitative analysis, the strengths, and weaknesses of the evaluation of the involvement of global trade in the circular economy model were examined. The qualitative analysis is flexible and allows the approach to be adapted as new information was gathered. For this reason, the analysis was refined to the most relevant aspects of the study. The circular economy model in global trade is seen in its entirety through the lens of qualitative analysis. It was about understanding the nuances of the model and its impact on different stakeholders such as corporations, governments, and consumers. The validity of the results of the study was enhanced using qualitative analysis. By using multiple data sources, including interviews, observations and case studies, the findings were verified to be valid. However, the findings of qualitative research are difficult to generalize. The findings of a qualitative study are specific to the setting in which the research was conducted and cannot be applied to other situations. However, qualitative analysis is subjective, and conclusions may be influenced by the biases and interpretations of a particular author. Qualitative analysis required a limited sample size, which is what limits the generalizability of the results. The qualitative assessment of global trade engagement provided comprehensive insights into the implementation and effect of the circular economy model. Although it had limitations, including poor generalizability and subjectivity, these shortcomings were mitigated using multiple data sources. Overall, the qualitative analysis provided a valuable tool for evaluating the circular economy model in global trade.

3. Results

The analysis looked at how different factors can affect private investment and value added, how much money is earned from business activity. It looked at how much packaging waste per person, how much of this packaging waste is recycled by households, and how much municipal waste is recycled per person. It has been found that if there is more packaging waste per person and more of this packaging households recycle more of this packaging, then private investment and gross value-added increase. However, if more municipal waste is recycled, then private investment and gross value added may decrease. The amount of municipal waste per person does not seem to have much effect (Table 2).

Table 2. Ordinary least square

	Coefficient	Std. Error	t-ratio	p-value
Const	1,985.68	12.3008	161.4	<0.0001
Private investment and gross value	7.37568e-05	6.98939e-05	1.055	0.3508
Generation of packaging waste per ca	0.0346150	0.0784984	0.4410	0.6820
Recycling rate of packaging waste	−0.0987964	0.226610	−0.4360	0.6854
Recycling rate of municipal waste	0.577534	0.110246	5.239	0.0063
Generation of municipal waste per ca	−0.00757182	0.0140303	−0.5397	0.6181
Mean dependent var	2015.500	S.D. var	dependent	3.027650
Sum squared resid	0.343068	S.E. of reg.	S.E. of reg.	0.292860
R-squared	0.995842	Adjusted	R-squared	0.990644
F (5, 4)	191.5817	P-value(F)	P-value(F)	0.000075
Log-likelihood	2.672675	Akaike criterion	Akaike criterion	6.654650
Schwarz criterion	8.470161	Hannan-Quinn	Hannan-Quinn	4.663040

y1t = 89,596.5 + 947.402 x1t -2,836.59 x2t + 808.174 x3t + 47.7851 x4t + ut

y1t = Private investment and gross value added related to circular economy sectors (m€)

x1t = Generation of packaging waste per capita (kg) per capita

x2t = Recycling rate of packaging waste by type of packaging (%)

x3t = Recycling rate of municipal waste (%)

x4t = Generation of municipal waste per capita (kg) per capita

If all the variables are 0 then the value of Private investment and gross value added to circular economy sectors will be 89,596.5 m€. If only Generation of packaging waste per capita (kg) per capita increased by 1 unit, then private investment and gross value added related to circular economy sectors increased by 947.402. If recycling rate of packaging waste by type of packaging increased by 1% then private investment and gross value added related to circular economy sectors decreased by -2,836.59. If recycling rate of municipal waste increased by 1% then private investment and gross value added related to circular economy sectors increased by 808.174. If generation of municipal waste per capita increased by 1 unit then private investment and gross value added related to circular economy sectors increased by 47.7851. The P-value is 0.000074 which is much less than 0.05, so this is an appropriate model.

Circular economy goes beyond just waste management. The underlying principle involves rethinking and redesigning economic systems to not only eliminate waste in its physical form, but to address inefficiencies in resource use. There are a number of benefits to investing in circular economy, even in a zero-waste scenario. Circular economy promotes resource efficiency and reduces dependence on raw materials. This is particularly important given the scarcity of many resources and the increasing volatility of their supply chains. Investment in the circular economy sector promotes innovation in product design, materials science and supply chain management. These innovations support economic diversification, creating new markets and jobs. The circular economy reduces the impact of resource price volatility and supply chain disruptions, leading to a more stable and resilient economy. Reducing resource extraction and waste also has clear environmental benefits, including lower greenhouse gas emissions, reduced pollution and the preservation of natural ecosystems. From a global trade perspective, engaging in circular economy practices can increase a country's competitiveness in global markets. It demonstrates a commitment to sustainable practices that are increasingly valued by consumers and international trading partners. Circular economy strategies can lead to social benefits, including job creation in new industries related to recycling, upcycling and sustainable product design. Even in a hypothetical zero-waste scenario, the circular economy offers a comprehensive framework for sustainable economic development. It not only addresses environmental issues but also contributes to economic resilience, innovation and social well-being.

The correlation between the increase in recycling rates and the decrease in private investment and gross value added in the circular economy sectors requires a nuanced understanding. It is essential to take into account that the circular economy involves various interrelated elements, including resource efficiency, innovation and economic diversification. Therefore, a simple causal relationship between increased recycling rates and reduced investment may not capture the complexity of the circular economy. It is necessary to explore other influencing factors such as market dynamics, policy frameworks, technological advances and global economic trends that may also play a significant role in this observed phenomenon. The relationship between waste generation and investment in the circular economy sectors is not as straightforward as the causal link that would suggest that "more investment requires more waste". The observed correlation in the data may suggest differential dynamics, where increased waste generation may stimulate investment in circular economy practices, but this does not inherently imply that waste generation is a desirable or necessary condition for such investment. Thus, while increased waste production may temporarily stimulate investment in the circular economy sector due to the immediate demand for waste management solutions, the longer-term objective is to create a more sustainable economic system that thrives on the basis of lower resource use and waste production. The focus should be on creating a regenerative economy in which waste is minimised and resources are continuously reused, creating a net positive impact on the economy and the environment.

Table 3. Heteroskedasticity-corrected

	Coefficient	Std. Error	t-ratio	p-value
Const	116,613	41,210.4	2.830	0.0367
Generation of packaging waste per ca	1,145.63	182.668	6.272	0.0015
Recycling rate of packaging waste	−2,987.67	445.674	−6.704	0.0011
Recycling rate of municipal waste	614.248	413.036	1.487	0.1971
Generation of municipal waste per ca	−36.2648	59.8413	−0.6060	0.5710
	Statistics based on the weighted data			
Sum squared resid	6.652792		S.E. of regression	1.153498
R-squared	0.996389		Adjusted R-squared	0.993501
F(4, 5)	344.9596		P-value(F)	2.73e-06
Log-likelihood	−12.15164		Akaike criterion	34.30329
Schwarz criterion	35.81621		Hannan-Quinn	32.64361
	Statistics based on the original data			
Mean dependent var	120,820.0		S.D. dependent var	12,007.39
Sum squared resid	22,399,714		S.E. of regression	2,116.588

The output shows the results of running a LASSO regression using the alternating direction method of multipliers (ADMM) algorithm on a dataset with 10 observations and a dependent variable called Private investment and gross value added. The goal of LASSO regression is to select a subset of independent variables that are most important for predicting the dependent variable, while also reducing the impact of any irrelevant variables. The lambda value used in this regression is 0.476095, which corresponds to a lambda/n ratio of 0.04761. The degree of freedom (df) is 1, and the criterion value is 0.386667. The R-squared value is 0.68, indicating that the model explains 68% of the variation in the dependent variable. The Bayesian Information Criterion (BIC) is a measure of model fit that balances the trade-off between goodness of fit and model complexity. In this case, the BIC value is 19.2871 for a lambda-fraction of 0.5. The lower the BIC value, the better the model fit. The LASSO coefficients show the estimated effect of the independent variables on the dependent variable. The intercept is 12,758.9 and the only non-zero coefficient is for the independent variable called "Generation of packaging waste per capita", which has a coefficient of 650.578. This suggests that the generation of packaging waste per capita is an important predictor of private investment and gross value added.

Private investment can lead to increased economic activity, which can lead to increased municipal waste and packaging waste production (Fig 1). However, private investment can also lead to the development of more efficient and sustainable waste management practices, which can contribute to a reduction in waste generation, the total amount of municipal waste and packaging waste produced.

The concept of engaging in global trade within the circular economy model emphasises the recycling and reuse of materials and resources within the economy. An evaluation of this model was also carried out using qualitative analysis. The qualitative analysis sheds light on the barriers, benefits and opportunities that the circular economy model presents in global trade. Data research shows that studies on the intersection of the circular economy and the

global trade is gradually increasing, despite the low baseline. Eighty percent or more of articles and publications were produced during 2019-2021 (Barrie & Schröder, 2022). Both the academic and the so-called grey literature account for most of the published work (mainly including publications by international organisations). In the global circular economy, revenues from used, leased, and refurbished products alone reached approximately $339 billion in 2022. This is expected to double in 2026 (Mandpe et al., 2023).

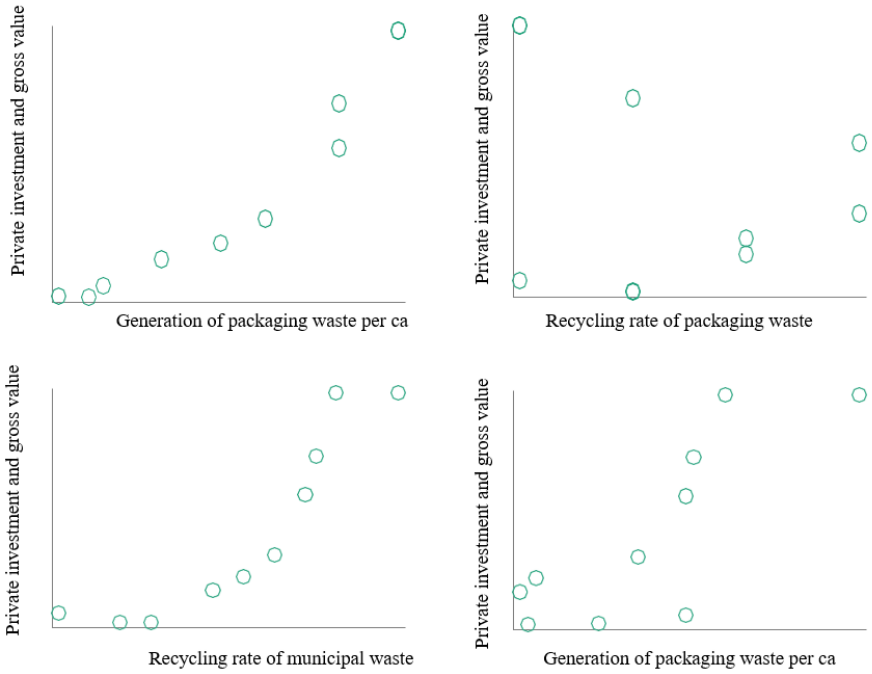

Figure 1. Scatter plot for variables (GRETL)

The global trade in plastic waste increased sharply after 1990 and peaked between 2006 and 2016. This was followed by a period of stability in world trade, with imports gradually declining. The Green Fence campaign, leading to a reduction in the amount of plastic trash that can be dumped in China and the subsequent shipment of this trash back to the countries of origin, was a major factor influencing the global decline in exports. The global volume of plastic imports and exports has been affected by the lack of waste disposal facilities elsewhere, in most cases, plastic waste is sent rather than being imported. The inability of countries to process their plastic waste is indicative of the lack of systematic management of plastic waste. In 2020, EU Member States exported 38.4 million tonnes of recyclables (including recyclable waste and scrap and secondary raw materials) to non-EU countries. These exports have been on the rise since 2004 and are expected to peak in 2020 (an increase of 70% compared to 2004 levels). In contrast, the European Union (EU) imported 44.7 million tonnes of recyclables from non-EU countries in 2020, a decrease of 0.2 per cent from 45.0 million tonnes in 2019 and an increase of about 2 per cent from 33.8 million tonnes in 2004 (43.7 million tonnes) (Midova et al., 2023).

4. Discussion

One of the main objectives of the circular economy is to reduce environmental damage (Konietzko et al., 2020), which is well known as one of the area's most susceptible to external

costs. This shows the importance of global trade as an important element of the circular economy for businesses (OECD, 2018), which are the source of negative externalities if circular economy businesses and business models are to prosper. There are many ways of looking at global trade and its role in the circular economy. The study focused on a circular economy model that examines global trade practices. There is a link between the private and public sectors, investment and gross value added, including the factors that can influence this relationship (Nguyen & Trinh, 2018). Municipal waste recycling rates, private investment and gross value added are also considered important elements of the transition of the global business model to a circular economy in the study (Hysa et al., 2020). Various factors can affect trade in the context of the circular economy (Pomberger et al., 2017). An enabling financial environment, regardless of the source of funding, promotes sustainable development. In many cases, it is investment, whether at the state, business, or household level, that is the limiting factor in efforts to achieve circularity, even though it is an integral part of any plan to address circularity (Agyapong & Tweneboah, 2023).

Another important element of the model is the rate of waste and, relatedly, the rate of recycling. Waste management and recycling rates are important elements of the transition to a circular economy, with reference to the priority areas of the Central Europe Action Plan (European Commission, 2015), and therefore need to be given due consideration when changing the business model. An important indicator here is the level of packaging waste per person, how much of this packaging waste is recycled by households and how much municipal waste is recycled per person. It was found that higher recycling rates per person and higher levels of recycling by households increases private investment and gross value added. The quality of waste management directly affects the profitability of companies, as confirmed by a study (Danon et al., 2022). A further important prerequisite for the transition to a circular economy is investment ("The New Industrial Strategy for Europe," 2021).and in this context also innovation (Aid et al., 2016).

The results of the paper are consistent with some other recent studies in which the authors developed models for the transition to a circular economy. In the first study (Busu & Trica, 2019) circular materials, municipal waste, trade in circular materials, labour productivity, environmental tax and resource productivity were all significant and positive for circular economic growth. A second study (Hill et al., 2020) described that resource productivity, recycling rates, environmental employment and innovation are also important for further economic and environmental growth. Other studies confirm that the importance of recycling rates and environmental innovation are also important factors for sustainable development and economic stability (Busu & Nedelcu, 2018; Lieder & Rashid, 2016). Similar to (Murray et al., 2017) and (Busu & Nedelcu, 2018), our results conclude that recycling rates have a positive impact on the transition to a circular economy.

5. Conclusion

Circular business models must be recognised as an integral part of the economy and must be given the resources they deserve. The importance of classifying indigenous materials according to aspects of business strategy design highlights the need to understand the

fundamentals of circular business models. This is essential for understanding the many forms that circular business models can take on and the different ways in which they can be implemented. According to the criterion Circular Business Model: Synthesis and Framework for growth, there should be a single model or framework that guides the creation and implementation of those models. Circular business models can be scaled and expanded by using a framework based on a synthesis of current knowledge and best practices.

The study investigated how global trade affects the transition to a more resource-efficient circular economy. The final question to be answered is how circular economy and trade policies could be linked to inspire a shift in resource use away from economic growth at the global level without causing additional barriers to global trade as well as undesirable environmental consequences. The small amount of previous research that has been published on this topic provides a strong incentive for further investigation in this area. Private investment can contribute to the growth of businesses and industries that produce goods, including packaged products. As businesses expand and produce more goods, they may also produce more packaging waste as a by-product of their production processes. Similarly, GVA can be an indicator of the level of economic activity in a country in a particular sector, including manufacturing and packaging. As the value of goods produced in these industries increases, this may also lead to an increase in the amount of goods produced and packaging waste generated. LASSO regression using the ADMM algorithm identified one significant predictor for the dependent variable, effectively reducing the influence of all irrelevant variables. The findings can help in making decisions on how to promote economic growth through a circular economy with environmental care.

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