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ASSESSMENT OF ENVIRONMENTAL AND ECONOMIC EFFICIENCY OF INNOVATIVE CIRCULAR BUSINESS MODELS IN THE RETAIL SECTOR

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Introduction. The modern global economy is confronted with unprecedented challenges arising from the accelerated depletion of natural resources, increasing waste volumes, and growing anthropogenic impacts on the environment, which contribute to climate change and the degradation of ecosystems. The traditional linear model of production and consumption, commonly summarized as "take, make, dispose", has proven unsustainable and insufficient for ensuring long-term economic and environmental prosperity. In response to these challenges, the concept of the circular economy (CE) has gained increasing relevance, promoting a fundamental shift from end-of-life disposal toward strategies of waste minimization, reuse, repair, and recycling, thereby preserving the value of materials for as long as possible[1][2].

In this context, the retail sector plays a key role[3]. As the link between producers and end consumers, retail not only generates significant amounts of waste (packaging, unsold goods, returns, logistics losses), but also has enormous potential to influence the entire value chain and shape sustainable consumer habits. The implementation of CE principles in retail is becoming not just a matter of corporate social responsibility, but also a strategic imperative that can improve operational efficiency, reduce risks, strengthen brand image and open up new sources of revenue amid growing demand for environmentally responsible goods and services.

However, the transition to circularity cannot be successful without ensuring its economic sustainability. Environmental initiatives must be inextricably linked to the creation of viable business models capable of generating profits and ensuring long-term competitiveness. The transition from the paradigm of 'environmental costs' to 'investments in circularity' requires the development and evaluation of innovative approaches that not only minimize negative environmental impacts but also have a solid

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[1] Maitre-Ekern E. "Re-thinking producer responsibility for a sustainable circular economy from extended producer responsibility to pre-market producer responsibility". J. Clean. Prod, 286, 125454, 2021. https://doi.org/10.1016/j.jclepro.2020.125454

[2] Liu L., Liang Y., Song Q., Li J.. "A review of waste prevention through 3R under the concept of circular economy in China". J. Mater. Cycles Waste Manag, 19(4), 1314-1323. 2017. https://doi.org/10.1007/s10163-017-0606-4

[3] Sonar H., Sarkar B.D., Joshi P., Ghag N., Choubey V., and Jagtap S.. "Barriers to reverse logistics adoption in circular economy: An integrated approach for sustainable development". CLSCN, 12, 100165, 2024. https://doi.org/10.1016/j.clscn.2024.100165

economic foundation. Only such models can be scaled up and integrated into the core business of retailers.

Various circular business models are already being actively developed and tested in the retail sector. The most popular ones include: rental and hire of goods (e.g. clothing, electronics, tools), which extend the life of the product and monetize its use; take-back and recycling programs for waste or obsolete products, which return materials to the production cycle; repair and restoration services that encourage reuse; platforms for reselling (secondhand) and exchanging used items; and refill models for packaging[4]. The implementation of these models, however, raises an important question about their actual effectiveness. The purpose of this study is to assess the potential for implementing circular business models in the retail sector using the example of the Russian home and garden retailer Lemana PRO. In this study, we analyze the comparative ecological and economic efficiency of the two most promising business models: the ‘rental’ model and the ‘recycling’ model.

Methodology. To assess the economic efficiency of these business models, a traditional economic analysis method was used, while environmental efficiency was assessed using a life cycle analysis methodology. To estimate the potential revenue of the rental model, data on the number of equipment rental requests in the region under study was obtained from the Yandex search engine. To estimate the potential revenue of the recycling model, pilot marketing studies of the secondary materials market were conducted.

Results. The analysis of the "Rent" model revealed its significant potential as a revenue-generating. By leveraging market demand data from sources like Yandex Wordstat for Moscow, the study showed that a tool rental service could generate a positive Net Present Value (NPV) over a 12-month period, indicating a profitable project. It should be noted, that the estimates were made based on the lower threshold of demand. The calculations included only the 10 most popular non-seasonal items such as hammer drills, grinding machines, construction dryers, construction vacuum cleaners, welding machines, chasers, jackhammers, lawn mowers, metal detectors, and drills. Sensitivity analysis showed that the model remains profitable even with lower tool utilization rates. At the lowest rate (35%), the project becomes profitable in the sixth month. As for the environmental efficiency of this model, it can be assessed by the indicator of the reduced negative impact on the environment (Avoided Environmental Impact) from the unrealized production and distribution of the tool that was not used (was not purchased).

The economic efficiency of the recycling model was calculated by comparing two different financial scenarios: outsourcing and in-house processing. The analysis did

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[4] Sonar H., Sarkar B.D., Joshi P., Ghag N., Choubey V., and Jagtap S.. “Barriers to reverse logistics adoption in circular economy: An integrated approach for sustainable development”. CLSCN, 12, 100165, 2024. https://doi.org/10.1016/j.clscn.2024.100165

not rely on the company's past performance but on the authors' own calculations and assumptions.

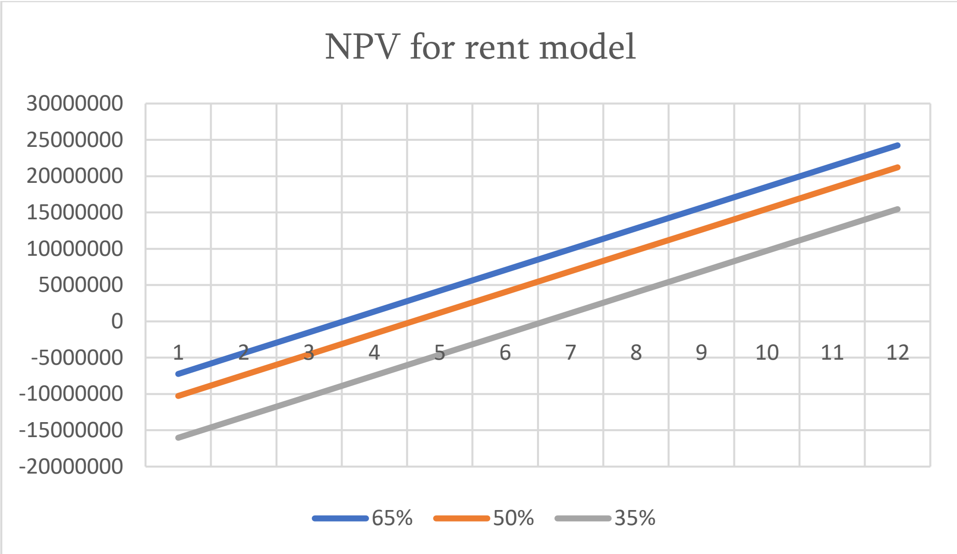

Figure 1. NPV of rental service project with different utilization rates[5]

Scenario 1: Outsourcing waste management operations to licensed third-party operators. In this case, Lemana-Pro will focus on collection and primary sorting, and then transfer the waste to specialized companies for further processing, recycling or disposal.

Scenario 2: Organizing its own (in-house) system of collection, sorting, pre-treatment (pressing, shredding, crushing) and subsequent sale of secondary material resources. In this scenario, part of the waste will be processed directly on the premises of the store or in its logistics center.

For the purposes of this analysis, we will assume the conventional retail space of a typical Lemana-Pro hypermarket to be 12,000 m². Based on data from[6], for industrial goods stores the waste accumulation rate (N) is 0.15 m³/year per m² of retail space (S), and the average density (P) is 200 kg/m³. Then, the total mass of waste can be estimated as follows:

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[5] Authors' own calculations based on the methodological approaches discussed in Ratner, S. V., & Mamedov, A. A. (2022). Eco-efficiency assessment models in the circular economy. Ecological Modelling, 476, 110–125.
Ratner, S. V., & Klochkov, Y. S. (2021). Sustainability of recycling business models in Russia. Resources, Conservation & Recycling, 169, 105–118.
OECD. (2020). Business Models for the Circular Economy. OECD Publishing.
[6] Solid Waste - Retail Industry Leaders Association, Available online: https://www.rila.org/retail-compliance-center/retail-solid-waste (accessed on 30 July 2025).

Table 1

Estimated annual waste volumes and composition for a typical Lemana-Pro store[7]

Waste type	Estimated share (%)	Estimated annual volume (tons)	Average cost/income per ton (RUB) Scenario 1	Total estimated annual costs/income (RUB) Scenario 1
Packaging cardboard	35%	126	-12 000 (income from sales)	-1 512 000
Plastic	15%	54	-15 000 (income from sales)	-810 000
Dismantled building materials	20%	72	400 (cost of disposal)	28 800
Electronic waste (EWEE)	5%	18	15 000 (cost of disposal)	270 000
Paint waste	2%	7.2	20 000 (cost of disposal)	144 000
Other/mixed waste	23%	82.8	900 (cost of disposal)	74 520
Total	100%	360		-1 804 680

M=S×N×P=12000 m2×0.15 m3/year/m2×200 kg/m3=360000 kg/year=360 tons/year.

Further, based on general data on the composition of waste from large retail[8] and the specifics of construction hypermarkets, the following composition of waste can be assumed (table 1).

The costs in Scenario 1 (outsourcing) are mainly related to the payment of third-party services for waste removal, transportation and disposal. They are also systematized

[7] Authors' own calculations based on the methodological approaches discussed in Crystal of purity: Disposal of construction waste. Available online: https://www.ekosferaplus.ru/utilizatsiya-musora/utilizatsiya-stroitelnogo-musora/ (accessed on 30 July 2025).
Ekoumwelt. Available online: https://ekoumwelt.ru/services/musor/tbo (accessed on 30 July 2025).
Vtorcentr. Available online: https://vtor.center/czenyi-na-makulaturu (accessed on 30 July 2025).
Production of presses, crushers. Reception of polymers. Available online: https://1-top.ru/othody/priem_plastika (accessed on 30 July 2025).
AMD Group. Available online: https://kupi-othodov.ru/news/7-prajs (accessed on 30 July 2025).
Disposal of hazardous waste. Available online: https://ekos.pro/price (accessed on 30 July 2025).
STROYSNAB28. Available online: https://keramzit-pesok.ru/sheben/vtorichnyj-shcheben/ (accessed on 30 July 2025).

[8] Sustainable Retail Waste Management: Eco-Friendly Practices for the Retail Sector, https://www.actenviro.com/retail-industry-waste-management/ (accessed on 30 July 2025).

by category in Table 1. Average market values of costs/incomes are taken from literature and Internet sources.

Thus, if sorting is effective and cardboard and plastic can be sold, outsourcing can generate net income (RUB 1,804,680 per year per hypermarket), despite the costs of hazardous and mixed waste disposal.

Table 2

CAPEX and OPEX of recycling model in Scenario 2[9]

Equipment/cost category	Quantity	Estimated unit cost (RUB)	Total cost (rub.)
CAPEX (Total)			4 188 000
Cardboard/Plastic Press	2	240 000	480 000
Plastic shredder	1	1 600 000	1 600 000
Construction waste crusher	1	1 000 000	1 000 000
Other infrastructure	1	500 000	500 000
Installation costs (10% of equipment)	-	-	308 000
Initial Licensing	-	-	300 000
OPEX (total)			7 520 920
Personnel costs	3 sorters, 2 operators	90 000 70 000	4 920 000
Energy consumption	160 kW, 320,000 kWh/year	6 rub./kWh	1 920 000
Maintenance and consumables	3% of the cost of the equipment		92 400
Internal logistics			100 000
Residual/hazardous waste disposal	Electronic waste (EW): 18 tons Paint: 7.2 tons Other/mixed waste: 82.8 tons	15,000 rubles/ton 20,000 rubles/ton 900 rubles/ton	488 520

However, note that despite the apparent simplicity, the fragmentation of waste management services in Russia (many companies for different types of waste, different pricing structures) can lead to increased administrative costs for managing multiple contracts and ensuring consistent quality of service for all waste streams. This complexity can offset some of the supposed simplicity.

[9] Authors' own calculation

Next, consider Scenario 2 - organizing companies' own recycling. In this scenario, Lemana-Pro invests in its own equipment and personnel for on-site waste pre-treatment, with the aim of reducing the volume of waste removed and generating income from the sale of secondary raw materials.

Initial investment in equipment and infrastructure (capital expenditure, CAPEX) is a key element for the in-house recycling scenario and consists of the cost of equipment, start-up costs and licensing costs for the collection, processing and disposal of waste of hazard classes I-IV (table 2). Operating expenses (OPEX) will consist of personnel costs, energy, maintenance and consumables, internal logistics and disposal of residual waste. Personnel costs will include wages for sorters, press or other equipment operators and management costs, which can be neglected (Table 2).

The estimations of the potential income from the sale of secondary material resources based on market data are presented in Table 3.

Table 3

The potential income from the sale of secondary material resources in Scenario 2[10]

Waste type	Estimated annual volume (tons)	Average income per ton (RUB) in Scenario 2	Total estimated annual income (RUB) Scenario 2
Packaging cardboard	126	12 000	1 512 000
Plastic	54	15 000	810 000
Dismantled building materials	72	533	38 376
Total			2 360 376

Therefore, the annual operating costs of recycling exceed the potential revenue from selling recycled materials (net annual financial result is -5 998 144 RUB). Sensitivity analysis (±15% revenue, ±10% OPEX) shows that even in the optimistic scenario, in-house recycling remains unprofitable. This confirms that, in the in-house recycling scenario, the high initial capital costs of specialized equipment (shredders, crushers) combined with ongoing labor and energy costs make a full-fledged in-house recycling operation a significant financial commitment. This model is likely to be economically viable only for very large volumes of specific, high-value waste streams where the revenue from selling recycled materials significantly outweighs the operating costs and amortized capital investment. For low-volume or hazardous waste, the financial justification for in-house recycling becomes extremely difficult.

As for the assessment of the environmental efficiency of competing business models, for the Rental model it is assessed based on the indicator of the reduced negative impact on the environment (Avoided Environmental Impact) from the unrealized

[10] Authors' own calculation based on market data

production and distribution of the tool that was not used (was not purchased). As a baseline assessment of the negative impact on the environment over the entire life cycle of the tools (LCA), the data from source[11] were used, which were then recalculated for the weight and quantity of all types of tools that are removed from use (and, accordingly, from production) due to the rental model.

Table 4

Indicators of ecological and economic efficiency of the rental business model and the recycling business model (in two scenarios)[12]

Parameter	Rent	In-house Recycling	Outsourcing Recycling
CAPEX	10 102 500 RUB	46 068 000 RUB	0 RUB
Net annual income per year	From 15 456 825 to 60 615 000 RUB	-65 979 584 RUB	19 851 480 RUB
Avoided CO_2 emissions (annual)	502.52 kg CO_2 eq	6 114.9 ton CO_2 eq	6 114.9 ton CO_2 eq
Additional avoided environmental impact	1,75 kg PM2.5 eq 11877,6 kg CFC11 eq	Water consumption 34 650 m3 Preventing toxic waste from entering soil and water (n/a)	Water consumption 34 650 m3 Preventing toxic waste from entering soil and water (n/a)

For the Recycling model, data from various sources were used[13][14][15], mainly on energy saving, which can then be converted into CO_2 emission reductions using average emissions from electricity generation in Russia[16]. The final estimates of economic and environmental parameters for both models are presented in Table 4. Note that all

[11] Briones F.A.B. "Life Cycle Assessment of a Hand-Held Power Tool: Battery Nutrunner Case Study". Maters Thesis. KTH Royal Institute of Technology. Stockholm, Sweden, June 2024. Available online: https://www.diva-portal.org/smash/get/diva2:1894136/FULLTEXT01.pdf (accessed on 30 July 2025).

[12] Authors' own calculation

[13] Marczak H. "Energy inputs on the production of plastic products". J. Ecol. Eng, 23(9), 146-156. 2022. DOI 10.12911/22998993/151815

[14] Challenge Boxes and Packaging. Available online: https://www.challengepackaging.co.uk/blog/benefits-of-recycling-cardboard/ (accessed on 30 July 2025).

[15] Geneva Environment Network. Available online: https://www.genevaenvironmentnetwork.org/resources/updates/the-growing-environmental-risks-of-e-waste/ (accessed on 30 July 2025).

[16] Marczak H. "Energy inputs on the production of plastic products". J. Ecol. Eng, 23(9), 146-156. 2022. DOI 10.12911/22998993/151815

estimates for the processing model, which were initially obtained for one typical Lemana PRO hypermarket, were multiplied by the number of hypermarkets in the Moscow region for comparability of the models.

Analyzing the calculation data, we can conclude that the economic efficiency of the "Rent" model is significantly higher than the economic efficiency of the "Recycling" model, since its net annual income is lower only in the case of the most pessimistic scenario. In the case of the optimistic scenario, the net annual income of this model may exceed the similar indicator of the "Recycling" model by more than 3 times. At the same time, the environmental efficiency of the "Rent" model, according to our calculations, gives very insignificant advantages, which, according to comparable indicators, are lower than that of the competing business model by 12 thousand times.

Discussion and Policy Implications. Based on the comparative environmental and economic analysis and sensitivity assessment, it is clear that there is no universal solution for choosing a circular business model for Lehman Pro. The large discrepancy in assessments for the two most important criteria, the wide variety of waste streams, from high-volume cardboard to low-volume but highly hazardous paints and varnishes, as well as the different regulatory and market conditions associated with each of them, require a differentiated strategy. Therefore, as the most effective and strategically sound solution for Lehman Pro, we can propose the development of a hybrid model combining elements of rental, in-house recycling and outsourced recycling models.

The outsourced recycling model is recommended for the following hazardous and complex waste streams, as well as for low-volume fractions:

1) Electronic waste (EW). Due to the complex regulatory requirements (Order of the Ministry of Natural Resources No. 173, GOST R 70146-2022), high costs for specialized equipment and li-censing, as well as significant environmental and safety risks, independent recycling of EW is im-practical. Therefore, this waste should be transferred to licensed specialized processors.

2) Paint and varnish waste. Being hazardous waste requiring special licensing and pre-treatment (drying), paint waste should be transferred to specialized companies. This approach minimizes the risks associated with the storage, processing and disposal of chemically active substances.

3) Low-volume or heavily contaminated types of plastic, as well as other/mixed waste. For these fractions, where the costs of sorting and pre-processing exceed the potential sales revenue, outsourcing remains the most cost-effective solution.

The in-house recycling model is recommended for high-volume, relatively clean and valuable waste streams, which include the following:

1) Packaging cardboard. On-site cardboard compaction will significantly reduce the volume, reduce removal costs and generate a stable income from the sale of recyclable materials. As the analysis in section 3.2 showed, investments in a waste paper press are relatively small and quickly pay for themselves due to reduced transportation costs and an increase in the value of recyclable materials.

2) PET, HDPE film. Similar to cardboard, on-site compaction and sorting of these types of plastic can be cost-effective. However, for more complex types of plastic that require shredding or granulation, the feasibility of in-house recycling will depend on the volume and market value. If the volumes of these types of plastic are large enough, then investing in a shredder may be justified.

3) Dismantled building materials. If the volumes of such waste from internal repairs or returns are significant and stable enough, and there is a strong market for recycled aggregate in the region, then investment in a crusher could be considered. However, this requires significant capital expenditure and the availability of appropriate space.

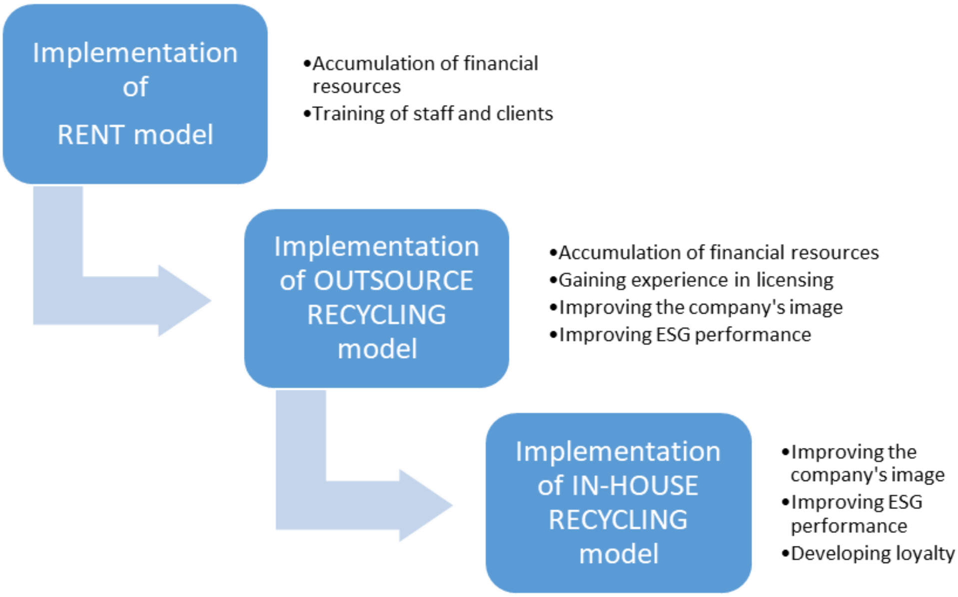

Figure 5. Hybrid circular business-model for Lemana PRO[17].

The most important principle for implementing this hybrid model, in our opinion, should be a phased approach that will allow for the accumulation of financial resources by developing, first of all, the most economically advantageous circular practices (Figure 5). A phased approach to implementation is critical to minimizing financial risks and allowing for iterative learning and adaptation. This ensures that the

[17] Bocken, N., de Pauw, I., Bakker, C., & Van der Grinten, B. (2016). Product design and business model strategies for a circular economy. Journal of Industrial and Production Engineering, 33(5), 308–320.
OECD. (2020). Business Models for the Circular Economy. OECD Publishing.
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rollout of complex circular initiatives is effective, efficient, and responsive to unforeseen challenges, rather than an expensive, high-risk approach of implementing all three components of a circular business model at once. Given the inherent complexity and significant investment required for a comprehensive circular economy transformation, a "one-shot implementation" approach would expose Lehmann Pro to excessive risk. Phased implementation allows for controlled experimentation, data collection, and continuous improvement of processes and offerings. This iterative learning curve is critical to ensuring that the implementation is effective and ultimately successful, minimizing potential financial losses and operational disruptions.

Conclusion. The key finding of the study is that a hybrid circular business model represents the most effective and strategically robust solution for Lemana Pro. The phased implementation of this model, which prioritizes economically viable practices such as product rental to generate resources for financing more environmentally beneficial initiatives, including in-house recycling, enables circular activities to evolve from cost centers into sources of profit and brand value. This approach facilitates a practical and sustainable transition toward a circular economy, even under the constraints imposed by the current economic and political environment. Moreover, the findings offer valuable guidance for other Russian retailers seeking to adopt circular economy principles within similarly challenging market conditions.

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ՄԱՐԱՏ ՀԱՐՈՒԹՅՈՒՆՅԱՆ

Համառոտագիր

Ժամանակակից պայմաններում բնական ռեսուրսների սպառման աճը, բնապահպանական պահանջների խստացումը և սպառողական վարքագծի փոփոխությունը ստիպում են վերանայել մանրածախ ոլորտի բիզնես-մոդելների կառուցվածքը՝ դրանք տեղավորելով շրջանաձև տնտեսության տրամաբանության մեջ: Մանրածախ ցանցերը հանդիսանում են թափոնների ձևավորման և առաջնային ռեսուրսների օգտագործման կարևոր օղակ, ինչի պատճառով նորարարական շրջանաձև մոդելների ներդրումն ունի ինչպես տնտեսական, այնպես էլ էկոլոգիական բարձր արդիականություն: Հոդվածի նպատակն է գնահատել մանրածախ ոլորտում կիրառվող շրջանաձև բիզնես-մոդելների շրջակա միջավայրի և տնտեսական արդյունավետությունը և ապացուցել դրանց կիրառելիության պայմանները: Նպատակին համապատասխան ձևակերպվել և լուծվել են հետևյալ խնդիրները՝ վերլուծել շրջանաձև տնտեսության և շրջանաձև բիզնես-մոդելների տեսական մոտեցումները, սահմանել էկոլոգիական և տնտեսական արդյունավետության ցուցիչները, կառուցել հաշվարկային սցենարներ տարբեր մոդելների համար և իրականացնել դրանց համեմատական գնահատում: Մեթոդաբանական մոտեցումը ներառում է ծախս–օգուտ վերլուծություն, ներդրումային նախագծերի գնահատման գործիքներ, շրջակա միջավայրի ազդեցության ցուցիչների կիրառություն, ինչպես նաև սցենարային վերլուծություն և միջազգային փորձի բենչմարքինգ: Վերլուծության արդյունքները ցույց են տալիս, որ վերամշակման, վերաօգտագործման և ծառայության վրա հիմնված մոդելները հնարավորություն են տալիս միաժամանակ նվազեցնել թափոնների ծավալը և CO_2 արտանետումները, բարձրացնել շահութաբերության մակարդակը և մեծացնել մանրածախ ընկերությունների կայունությունը: Սահմանված եզրակացությունները կարող են օգտագործվել կայունության կորպորատիվ ռազմավարությունների, ներդրումային որոշումների և պետական քաղաքականության միջոցառումների մշակման մեջ:

Բանալի բառեր: շրջանաձև տնտեսություն, բիզնես-մոդելներ, էկոլոգիական արդյունավետություն, տնտեսական արդյունավետություն, ռեսուրսախնայողություն, վերամշակում, մանրածախ ոլորտ

ОЦЕНКА ЭКОЛОГИЧЕСКОЙ И ЭКОНОМИЧЕСКОЙ ЭФФЕКТИВНОСТИ ИННОВАЦИОННЫХ ЦИРКУЛЯРНЫХ БИЗНЕС-МОДЕЛЕЙ В РОЗНИЧНОМ СЕКТОРЕ

СВЕТЛАНА РАТНЕР
МАРАТ АРУТЮНЯН

Анотация:

В условиях усиливающегося давления на природные ресурсы, ужесточения экологических требований и изменения потребительского поведения возрастает необходимость трансформации бизнес-моделей розничного сектора в соответствии с принципами циркулярной экономики. Розничные сети являются значимым источником образования отходов и интенсивного потребления первичных ресурсов, что делает внедрение инновационных циркулярных решений одновременно экономическим и экологическим приоритетом. Цель статьи заключается в оценке экологической и экономической эффективности циркулярных бизнес-моделей в розничной торговле и выявлении условий, при которых их использование становится выгодным для компаний. В соответствии с целью решаются следующие задачи: анализируются теоретические подходы к циркулярной экономике и циркулярным бизнес-моделям; уточняются показатели экологической и экономической эффективности; формируются расчетные сценарии для различных моделей обращения с отходами и использования продукции; проводится их сравнительный анализ. Методологическая база исследования включает элементы анализа «затраты–выгоды», методы оценки инвестиционных проектов, индикаторы экологического воздействия, а также сценарный подход и международный бенчмаркинг. Полученные результаты показывают, что модели, основанные на переработке, повторном использовании и сервисных схемах, позволяют одновременно сокращать объем отходов и выбросов CO_2, повышая прибыльность и устойчивость розничных компаний. Сформулированные выводы могут быть использованы при разработке корпоративных стратегий устойчивого развития, инвестиционных решений и мер государственной поддержки перехода розничного сектора к циркулярной экономике.

Ключевые слова: циркулярная экономика, бизнес-модели, экологическая эффективность, экономическая эффективность, устойчивое развитие, переработка, розничный сектор

ASSESSMENT OF ENVIRONMENTAL AND ECONOMIC EFFICIENCY OF INNOVATIVE CIRCULAR BUSINESS MODELS IN THE RETAIL SECTOR

SVETLANA RATNER
MARAT HARUTYUNYAN

Abstract

Growing pressure on natural resources, increasingly stringent environmental regulations, and changing consumer behavior necessitate a fundamental redesign of business models in the retail sector in accordance with circular economy principles. Retail chains are among the major generators of waste and intensive users of primary resources, making the adoption of innovative circular solutions both an environmental imperative and an economic priority. The purpose of this article is to assess the environmental and economic efficiency of innovative circular business models in the retail sector and to identify the conditions under which their implementation becomes economically viable for companies.

To achieve this objective, the study addresses the following tasks: (i) reviewing and systematizing theoretical approaches to the circular economy and circular business models; (ii) defining indicators for measuring environmental and economic efficiency; (iii) developing calculation scenarios for alternative waste management and product-use models; and (iv) conducting a comparative analysis of the results obtained. The methodological framework integrates cost-benefit analysis, investment appraisal techniques, and environmental impact indicators, complemented by scenario analysis and international benchmarking of circular economy practices.

The results demonstrate that business models based on recycling, reuse, and service-oriented schemes can simultaneously reduce waste generation and CO_2 emissions while enhancing the profitability and resilience of retail companies. The findings provide practical insights for the formulation of corporate sustainability strategies, the evaluation of investment decisions, and the design of public policy instruments aimed at supporting the transition of the retail sector toward a circular economy.

Keywords: circular economy, business models, environmental efficiency, economic efficiency, sustainability, recycling, retail sector