MANAGEMENT OF FINANCIAL RESULTS OF METALLURGICAL ENTERPRISES IN CONDITIONS OF GLOBAL SUSTAINABLE DEVELOPMENT

УПРАВЛІННЯ ФІНАНСОВИМИ РЕЗУЛЬТАТАМИ МЕТАЛУРГІЙНИХ ПІДПРИЄМСТВ В УМОВАХ ГЛОБАЛЬНОГО СТАЛОГО РОЗВИТКУ

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This research explores the financial implications of adopting circular economy principles in metallurgical production, specifically within the context of the Metinvest Corporation. It addresses the industry's reliance on resource-intensive technologies, including blast furnace (BF), basic oxygen furnace (BOF), and electric arc furnace (EAF) processes, all of which generate substantial by-products. Highlighting the potential of electronic waste and other end-of-life materials as resources, the study suggests that circular economy practices, including waste minimization and decarbonization, can shift the industry from a linear to a circular model. The research outlines the benefits of utilizing waste materials, including electronic waste, obsolete vehicles, and other end-of-life products, as potential resources for steel production. This approach aims to mitigate the ecological footprint of metallurgical processes and reduce the dependency on primary raw materials. The adoption of circular economy principles, characterized by the 3R approach (reduce, reuse, recycle) and the co-product concept, is projected to support global sustainable development goals by promoting resource efficiency, reducing emissions, and enhancing waste management. To analyze the economic benefits of implementing circular economy principles, the study applies a functional econometric model to assess the financial impact of various measures, including reducing material intensity and integrating decarbonization technologies. Despite the considerable investment in advanced technologies required for decarbonization and waste recycling, the model confirms that adopting these practices can lead to substantial long-term financial gains, with the potential to improve overall financial results by 42 % to 218 %, thereby aiding companies like Metinvest in reaching and surpassing break-even points. This research provides compelling evidence for the feasibility and value of circular economy models in the metallurgical industry, supporting sustainable growth and positive environmental outcomes.

Key words: *3 R + co-P (reduce, reuse, recycle, co-products), econometric model, by-products, decarbonization*

В статті розглянуті фінансові результати впровадження принципів циклічної економіки в металургійному виробництві, зокрема в контексті індикаторів холдингової групи Метінвест. Підкреслюючи потенціал металургійних відходів та інших відпрацьованих матеріалів як ресурсів, дослідження припускає, що практики циклічної економіки, включаючи мінімізацію відходів і декарбонізацію, можуть змінити модель галузі з лінійної на кругову. Дослідження констатує переваги використання відходів, включаючи відходи електроніки, автомобільної галузі та інших галузей промислового сектору, як потенційні ресурси для виробництва сталі. Запропонований підхід має на меті пом'якшити екологічний слід металургійних процесів і зменшити залежність від первинної сировини. Прийняття принципів циркулярної економіки, що характеризується підходом 3R (зменшення, повторне використання, переробка) і концепцією супутніх продуктів, передбачає підтримку глобальних цілей сталого розвитку шляхом сприяння ефективності використання ресурсів, скорочення викидів і покращення управління відходами. З метою виявлення економічних вигід від впровадження рівнів циркулярної економіки, дослідження застосовує функціональну економетричну модель для оцінки фінансового впливу, зокрема зниження матеріаломісткості та інтеграції технологій декарбонізації. Незважаючи на значні інвестиції в передові технології, необхідні для декарбонізації та переробки відходів, модель підтверджує, що впровадження цих практик може призвести до значних довгострокових фінансових прибутків із потенціалом покращення загальних фінансових результатів з 42 % до 218 %, реалізуючи вихід з точки беззбитковості корпорації та холдинги. Запропоноване дослідження надає переконливі докази доцільності та цінності моделей замкнутої економіки в металургійній промисловості, що підтримує стійке зростання та позитивні екологічні результати. Дослідження має на меті об'єднати різноманітний спектр інженерно-металургійних та управлінських рішень на основі всебічного огляду літератури, розглядаючи унікальні проблеми та включаючи відповідні тематичні дослідження в контекст циклічної економіки. Зрештою, ця стаття приносить кілька переваг завдяки практичним і корисним застосуванням. Визнання прогалин у літературі спонукає до подальших досліджень, сприяючи всебічному розумінню подальшого розвитку циркулярної економіки в металургійному секторі. Стратегічне планування рівнів розвитку циркулярної економіки: це чіткий механізм, який узгоджує фінансовий результат із перспективним баченням розвитку певного рівня циркулярної економіки. Міжгалузеве співробітництво: реалізація концепції циркулярної економіки стимулює стратегічне співробітництво металургії з іншими секторами національної економіки, спрямоване на формування сталого промислового симбіозу. Виявлення проблем надає цінну інформацію для органів місцевого самоврядування, допомагає сформувати вектор розвитку промислового сектору та можливі перспективи трансформації деяких старих промислових підприємств, регіонів зі значним відсотком первинного та вторинного сектору економіки.

Ключові слова: *3 R + co-P (зменшення, повторне використання, переробка, супутні продукти), економетрична модель, побічні продукти, декарбонізація*

Statement of the problem. Metallurgical production has a wide range of production processes, starting with the extraction of metal from all possible resources and ending with obtaining a finished steel product [1], using at the same time the main two types of technologies: based on blast furnace (BF) and basic oxygen furnace (BOF) and technological type of electric arc furnace (EAF) steel production. Each of them generates many different types of by-products [2]. The multitude of electronic equipment, cars, and other equipment have a life cycle of fatigue and ephemerality and are a potential resource of the metallurgical industry [3]. It can be convincingly argued that the accumulation of by-products poses a significant threat to the global sustainable development of mankind [4], their possible successful use in the future will ensure the transition from a simple linear model to an effective circular economy [5] and help metallurgical enterprises to obtain positive growing financial results [6].

Analysis of recent research and publications. Theoretical and methodological aspects of the application of the model with dummy variables for the analysis of the financial and economic activity of metallurgical enterprises were used by a significant number of scientists in their works: T. Haixia, W.Hongtu, C.Lin, S Feng [7], X. Wang, R. Deng, Y. Yang [8], R. Wu, Z. Tan, B. Lin [9], F. Flues, D. Rübbelke, S. Vögele [10].

The method of regression analysis with dummy variables is used in the metallurgical sector to: assess the impact of legal factors on production safety [7]; the spatio-temporal effect of prices on the loading of production capacities [8]; emission trading schemes for total carbon dioxide emissions [9]; the influence of economic factors on the energy efficiency of the metallurgical industry [10]. In our study, the dependence of the financial results of metallurgical enterprises on the factors of the conceptual model of the circular economy was formed.

Unfortunately, in the studies of scientists, there are no attempts to form the dependence of the financial results of metallurgical enterprises on the factors of the conceptual model of the circular economy, which is the task of our research.

Setting the task. The purpose of this study is to build a systematic approach to assessing the level of impact of circular economy development on the micro (improved financial performance) and macro levels (emergence and growth of the market for related products and their environmental impact). This study combines abstract and logical, bibliographic, and econometric analysis, which makes it possible to formulate reasonable results.

Presentation of the main research material. Based on the data from international organisations, centres, barometers, and sustainability reports of global metallurgical corporations, the levels of implementation of the circular economy in the activities of metallurgical corporations are analysed in detail (Table 3).

Based on the patterns of implementation of the circular economy in the activities of the metallurgical sector (Table 4), we will code the qualitative variables into one single active state

Based on the coding and material costs of corporations [11–16], we will form a specification of the dependence of the financial results of metallurgical enterprises on factors (Table 5), which will be the basis for calculating a functional econometric regression model.

Table 3

The level of implementation of the circular economy in the activities of the metallurgical sector

Metallurgical corporations	reuse	recycle	co-products
1	2	3	4
Metivest	carbon neutrality by 2050, as of 2023, decarbonization has not started **Conclusion: Absent**	100 % domestic steel scrap processing **Conclusion: complete recycling**	No processing of related products, sale of slag and dust **Conclusion: Absent**
Iterpipe	lack of decarbonization and green steel production **Conclusion: Absent**	100 % domestic steel scrap processing **Conclusion: complete recycling**	Partial processing of slag, sale of other related products **Conclusion: Partial**
Erdemir Group	carbon neutrality by 2050 **Conclusion: Initial stage**	100 % domestic steel scrap processing **Conclusion: complete recycling**	Unavailability of processing of related products, sale of slag **Conclusion: Partial**
Nippon steel	carbon neutrality by 2050 reduction of CO2 emissions by 15.2 million tons **Conclusion: Stage of development**	100 % recycling of domestic, industrial and obsolete steel scrap **Conclusion: complete recycling**	100 % recycling of by-products: 0 % steel dust emissions, fully recycles slag with “RHF” equipment **Conclusion: Full**
POSCO Holdings	reduction of CO^2 emissions by 30 % by 2030. and 0 % of carbon emissions by 2050 **Conclusion: Initial stage**	processing of steel scrap up to 500,000 tons (until 2025), investment in the project 20 billion won **Conclusion: complete recycling**	steel slag for the creation of a marine forest, for the production of fertilizer **Conclusion: Partial**

Continuation of table 1

1	2	3	4
ArcelorMittal	reduction of CO^2 emissions by 35 % by 2030. and achieve carbon neutrality by 2050 **Conclusion: Initial stage**	100 % processing of domestic steel scrap (1 million tons/year) **Conclusion: complete recycling**	sales of 200,000 tons/year of slag of construction industry **Conclusion: Partial**
China Baowu Steel Group	reduction of CO^2 emissions by 35 % by 2030. and achieve carbon neutrality by 2050 **Conclusion: Initial stage**	100 % processing of domestic, industrial and obsolete steel scrap (2 million tons/year, total investment in scrap processing 68.3 million dollars) **Conclusion: complete recycling**	Green, waste-free production, treatment of industrial wastewater 1 thousand tons/day **Conclusion: Full**
Emirates Steel	reducing the intensity of carbon emissions by 50 % by 2030. 0 % of carbon emissions by 2050 **Conclusion: Stage of development**	100 % processing of domestic steel scrap **Conclusion: complete recycling**	Partial processing or sale **Conclusion: Partial**
Steel Dynamics	reducing the intensity of carbon emissions by 20 % by 2025 **Conclusion: Initial stage**	100 % recycling of domestic steel scrap. 12 million tons of recycled scrap in 2021 **Conclusion: complete recycling**	Partial processing of related products **Conclusion: Partial**
Tata Steel	reduce CO2 emissions to 2 tons/1 ton of steel by 2025 **Conclusion: Initial stage**	100 % recycling of domestic steel scrap **Conclusion: complete recycling**	100 % recycling of related products **Conclusion: Partial**

Table 4

Coding of qualitative variables by one single active state

Corporations	Decarbonization or green steel	Stage of development	Initial stage	Processing of related products	Complete rework	Partial rework
Metivest	Absent	0	0	Absent	0	0
Iterpipe	Absent	0	0	Partial	0	1
Erdemir Group	Initial stage	0	1	Partial	0	1
Nippon steel	Stage of development	1	0	Full	1	0
POSCO Holdings	Initial stage	0	1	Partial	0	1
ArcelorMittal	Initial stage	0	1	Partial	0	1
China Baowu Steel Group	Initial stage	0	1	Full	1	0
Emirates Steel	Stage of development	1	0	Partial	0	1
Steel Dynamics	Initial stage	0	1	Partial	0	1
Tata Steel	Initial stage	0	1	Partial	1	0

Table 5

Specification of the functional econometric model of the dependence of financial results of metallurgical enterprises

Corporations	Net profit, billion dollars	Material capacity, thousands of dollars / ton	Stage of development	Initial stage	Complete rework	Partial rework
Metivest	–2,193	2,86	0	1	0	0
Iterpipe	0,204	1,06	0	0	0	1
Erdemir Group	0,657	0,578	0	1	0	1
Nippon steel	4,908	1,08	1	0	1	0
POSCO Holdings	0,382	0,381	0	1	0	1
ArcelorMittal	0,261	0,228	0	1	0	1
China Baowu Steel Group	5,293	0,741	0	1	1	0
Emirates Steel	0,138	0,757	1	0	0	1
Steel Dynamics	0,634	0,417	0	1	0	1
Tata Steel	4,944	0,2	0	1	1	0

As a result of the calculations, it has been obtained the following functional econometric model of financial results of metallurgical enterprises, defining the following characteristics of the model: parameters, level of significance of the model, total correlation coefficient, total determination coefficient.

The obtained F-statistic indicates the statistical significance of the model. The low p-value indicates the statistical significance of the model at the 0.05 level of significance. The multiple R = 0.9996, close to 1, indicates a high linear relationship between the independent and dependent variables. Approximately 99.93 % of the variation in the dependent variable is explained by the model, as evidenced by R^2. Overall, the model has a high explanatory power as the R^2 is very close to 1 and the multiple R is also high. The F-statistic and its p-value confirm the statistical significance of the model.

As a result of approbation of the functional econometric model on the example of the Metivest corporation, the following results were obtained (Table 7, Fig. 2.):

– implementing measures to reduce material intensity, the corporation will improve its financial results from -5.2203 million dollars to -2.9917 billion dollars, i.e. the growth will be 42 %;

Table 6

Functional econometric model of financial results of metallurgical enterprises

Regression coefficients					
y-intersection	**material capacity**	**Decarbonization (stage of development)**	**Decarbonization (initial stage)**	**By-product rework (full)**	**By-product rework (partial)**
-5,2203	0,7792	0,1474	0,7987	9,1621	4,5983
Model evaluation indicators					
F	Significance of F	df	Multiple R	R^2	
1201,3993	0,0000019	5	0.9996	0.9993	

Table 7

Forecast of the financial result based on the model with dummy variables (Metivest Corporation), billion hryvnias

Without the introduction of innovative changes	The result of reducing material capacity without high-quality components	Result (decarbonization initial stage)	Result (decarbonization stage of development)	Result (partial rework of byproducts and decarbonization stage of development)	Result (full rework of by-products, decarbonization stage of development)
-5,2203	-2,9917	-2,19	-2,8443	2,4083	6,1704

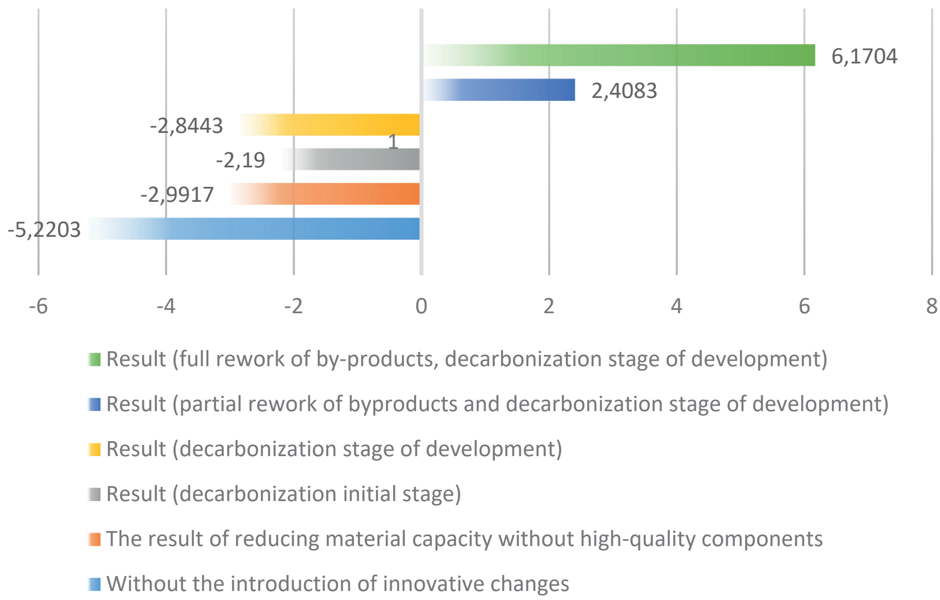

Figure 2. Forecast of the financial result based on a model with dummy variables (Metivest Corporation (million hryvnias)

– implementing decarbonization processes at the initial stage and having innovative technologies to reduce material intensity, the financial results are forecast to increase from -5.2203 billion dollars to -2.19 billion dollars, the growth will be 58 %;

– implementing decarbonization processes at the stage of development and having innovative technologies to reduce material intensity, the financial results are forecast to increase from -5.2203 billion dollars to -2.8443 billion dollars. The lower decarbonization effect of the development stage is explained by the significant investment that the corporation must make in carbon capture from the initial stage to the development stage, so most multinational companies avoid innovative projects to reduce the level of CO2 emissions;

– implementing decarbonization processes at the development stage, having innovative technologies to reduce material intensity and partially processing related products, the corporation will receive a projected increase in financial results from -5.2203 billion dollars to 2.4083 billion dollars (146 %);

– implementing decarbonization processes at the development stage, having innovative technologies to reduce material intensity and having a closed production cycle, the corporation will receive a forecast increase in financial results from -5.2203 billion dollars to 6.1704 billion dollars (218 %).

Conclusions. Formed functional econometric model of financial results of circular economy of metallurgical enterprises gives a clear representation of influence of introduction of circular economy levels on the final financial result of multinational companies. As a result of approbation of the functional econometric model on the example of the Metivest corporation, we received confirmation of the feasibility of implementing the concept of circular economy 3 R + co-P, the implementation of the processes of decarbonization and processing of related products in the considered corporation, the reduction of material consumption will ensure the growth of financial results almost twice, from 42 to 208 % and will provide the multinational company with a way out of the break-even point.

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