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Virginia Zhelyazkova**,** PhD. in Economic, Research Institute at the Bulgarian Academy of Sciences, Bulgaria, v.zhelyazkova@iki.bas.bg ; https://orcid.org/0000-0002-0434-2134**,** virginia.zhelyazkova@gmail.com
Yuri Suvaryan, D.Sc in Economics, Professor, National Academy of Sciences of Armenia, Yerevan, https://orcid.org/0009-0000-7908-9949, suvaryan@sci.am
Meri Manucharyan, PhD in Economics, M. Kotanyan Institute of Economics, Yerevan, Grigor Lusavorich 15, 0015, https://orcid.org/0000-0002-9814-5376, g.manucharyan@gmail.com, mmanucharyan@economics.sci.am
Hovhannes Asatryan, PhD in Economics, M. Kotanyan Institute of Economics, Yerevan, Grigor Lusavorich 15, 0015, https://orcid.org/0000-0002-9814-5376, hov97hov@gmail.com
Shogher Poghosyan, PhD in Economics, M. Kotanyan Institute of Economics, Yerevan, Grigor Lusavorich 15, 0015, https://orcid.org/0009-0000-4870-2560 shogher2002@yahoo.com
Bella Gabrielyan, PhD in Economics, M. Kotanyan Institute of Economics, Yerevan, Grigor Lusavorich 15, 0015, https://orcid.org/0000-0002-7428-7900 , bvgabrielyan@mail.ru

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M. Kotanyan Institute of Economics,
15 Surb Grigor Lusavorich Street
Yerevan 0015, Republic of Armenia
Tel. (+374 10) 58-19-71
E-mail: nas_ie@sci.am

CONTENT

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TRENDS IN THE DEVELOPMENT OF THE FOOD INDUSTRY IN THE REPUBLIC OF ARMENIA IN THE CONTEXT OF ENSURING FOOD SECURITY

Liana Azatyan[1], Rimma Asoyan[1,*]
[1] M. Kotanyan Institute of Economics

Abstract: *In the Republic of Armenia, the food industry is considered one of the key sectors of the economy, whose primary objective is to provide citizens with high-quality food products, as food represents a basic necessity, and both its quality and quantity determine people's health and intellectual capacity.*
In terms of essential food products (such as wheat, vegetable oil, sugar, and certain types of meat products) RA faces issues of self-sufficiency, which are compensated through imports. The food industry addresses food security challenges while simultaneously generating added value and creating new jobs. The food production sector is directly linked to agriculture, whose inherent risks inevitably affect the efficiency of the food industry.
The efficiency of the food industry also depends on the social status of the population. Due to insufficient financial resources, there is no demand from consumers for safer food.
The development of the food safety sector is one of the key processes within the agrarian policy implemented in the Armenian economy. Its goal is to ensure consumers are provided with high-quality and safe food products and to guarantee food security.
The relevance of this topic is determined by the importance of this issue.
The main objective of the article is to study the current state of the food industry in the Republic of Armenia.
The research was carried out using sectoral study methods, as well as descriptive, analytical, and statistical data analysis approaches.
As a result, practical recommendations are presented, including:

- *Improving sectoral legislation and aligning it with international standards;*
- *Ensuring control at all stages of the food industry;*
- *Implementing a system of continuous professional training for specialists;*
- *Increasing the level of public awareness among the population.*

Keywords: *food security, food industry, self-sufficiency, imports, processing, food safety, yield, soil fertility*.

Rimma Asoyan*
E-mail: asoyanrima@gmail.com

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Introduction

In the Republic of Armenia, the food industry is considered one of the important sectors of the economy, the purpose of which is to provide citizens with high-quality food products, since it is a basic necessity, and people's health and intellectual strength depend on its quality and quantity. In the RA, regarding essential food products such as wheat, vegetable oil, sugar, and certain types of meat products, there is a problem of self-sufficiency, which is compensated through imports of these products. Large quantities of beef, pork, poultry meat, wheat, milk powder, etc. are imported. The food industry solves food security issues while simultaneously ensuring added value and creating new jobs. The food production sector is directly related to the agricultural sector, the inevitable risks of which affect the efficiency of the food industry. Fluctuations in the social condition of the population also affect the consumption of food industry products. The relevance of the topic selection is determined by the importance of this issue.

The main purpose of the article is to study the current state of the food industry in the Republic of Armenia:

- The current state of the food industry and the importance of ensuring safe food supply have been studied,

- The level of self-sufficiency in food products and food imports in the RA have been studied,
- Based on the comparison of the obtained results, conclusions and recommendations have been provided.

Literature Review

The concept of food security originated in the 1970s and has been constantly evolving since then, reflecting its complexity and the difficulty of implementing it in changing political and operational environments. The concept of food security was first proposed in 1974 at the World Food Summit (WFS) and was defined as "the permanent availability at all times of sufficient supplies of basic foodstuffs to meet the sustainable growth of food consumption and to compensate for fluctuations in production and prices" [4]. According to this definition, food insecurity is caused by a lack of quantitative food resources and high international food prices.

In 1983, the concept of ensuring access to available resources was included in the concept, that is, "paying equal attention to both demand and supply: ensuring that all people have both physical and economic access to essential foodstuffs at all times" [5]. The idea behind this concept was that the determinant of food insecurity was not an inadequate supply of food, but inadequate control over food resources.

In 1996, the concept of food security was included and food security was defined as a situation where people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life [6].

Food insecurity, defined as the lack of access to sufficient, safe and nutritious food at all times for an active and healthy life, affects millions of people worldwide [7,8]. Food security is a holistic system that includes the physical availability of food (agricultural production and market conditions), access to food (economic and physical), stability (price and income shocks), and utilization (food security and nutritional knowledge). While people's ability to access food is determined by personal income and food prices, food security can deteriorate due to falling income levels, high food prices and/or food supply shocks.

Food insecurity is a major challenge worldwide. Given the importance of reducing food insecurity, many researchers have attempted to identify the main determinants of food security and food insecurity, focusing on the dimensions of food safety, availability, and accessibility.

V. Stany found that the causes of food insecurity are multiple: education, gender, income, food quantity, and it is necessary to encourage large-scale production through new technologies, access to food, education and finance, strengthening the capacities of farmer organizations, diversification of activities, access to resources by women, and development of agricultural markets for products and inputs [9].

N. Aziz examining the macroeconomic determinants of food insecurity in South Asian countries, concluded that increased production increases malnutrition and that national food access is not sufficient to reduce malnutrition unless poor people also have economic and physical access to food [10].

S. Lin emphasize the importance of the environment in addition to economic determinants and propose healthy dietary scenarios for Asian countries of different status, taking into account environmental impact, calorie intake, and income level [11].

Olufemi-Phillips consider the increase in food prices as the main determinant of food insecurity and propose to control prices and provide subsidies to low-income households to mitigate its impact [12].

There is almost no research on econometric estimates of the determinants of calorie insecurity in the case of Armenia. The data are mainly focused on food consumption statistics, such as the daily bread consumption of the population in Armenia. From this perspective, the research presented will provide an opportunity to examine the level of calorie insecurity of the RA population and identify its main determinants.

Methodology

The studies were conducted using methods of sectoral study, descriptive, analytical, and statistical data analysis. As a result, recommendations were presented.

Analysis

The goal of every state is to provide its citizens with high-quality food products, since food is a basic necessity, and people's health and intellectual strength depend on its quality and quantity. However, for socially vulnerable populations, the importance of quality is often pushed into the background, and the price of the product becomes more important. In such cases, the state must establish control over the food products produced, imported, and sold in the country. Taking into account the importance of all this, the Government of the Republic of Armenia established an approach in the RA Law "On Food Safety [8]." In the Republic of

Armenia, the food industry is considered one of the important sectors of the economy. After independence in the 1990s, when industrial development declined, the pace of development of the food industry began to grow. Table 1 presents the types and quantities of products produced in the RA.

Table 1

Production of Main Products by Types of Economic Activity[9]

	2020	2021	2022	2023	2024
Meat, 1000 tons	85	85	81	80	87
Sausages and similar meat products, tons	12666	12032	12413	13084	14358
Canned stewed meat, tons	1214	528	1149	815	616
Canned meat with vegetable and mixed vegetable products, tons	1582	197	574	956	617
Fish prepared or preserved by other methods, tons	253	478	257	206	265
Fruit and vegetable juices, 1000 liters	12107	17117	17976	23350	22618
Vegetables preserved for short-term storage, tons	19291	13417	11279	12509	10919
Processed and preserved fruits and nuts, tons	10338	10924	11921	10820	12551
Refined oils, without sediment, tons	274	171	32	4	4
Processed liquid milk, 1000 liters	7652	7300	7728	9407	9771
Butter and dairy pastes, tons	1500	1886	5077	4416	4170
Cheese, 1000 tons	23	29	37	23	26
Cottage cheese, tons	1879	1809	1867	2625	2386
Sour cream, tons	6934	6231	5531	5858	7358
Tan (fermented dairy drink), tons	3906	4863	6070	4609	4056
Ice cream and edible ice, tons	7580	8534	9187	9736	9884
Wheat and rye flour, 1000 tons	201	158	187	176	143
Groats, coarsely ground flour, grains, and other cereal crop products, tons	1562	1695	1821	1815	2403
Fresh bread (non-long-term storage), 1000 tons	269	264	266	265	263
Cakes, pastries, fresh flour confectionery products (non-long-term storage), and other confectionery products, tons	8994	8942	8781	8385	8963
Biscuits, gingerbread and similar products, sweet biscuits, waffles and wafer sheets, tons	3961	4161	5100	4747	4509
Refined cane or beet sugar, tons	28771	23255	66661	29854	53777
Chocolate and sugar confectionery, tons	9747	9943	9021	8077	7451
Table salt, 1000 tons	28	33	23	20	21
Cognac, 1000 liters of 100% alcohol	-	18679	21510	19691	19918
Whiskey, 1000 liters of 100% alcohol	-	269	593	3031	5218
Vodka, liqueur, and other alcoholic beverages, 1000 liters of 100% alcohol	-	2083	1563	1676	1490
Grape wine, 1000 liters	10656	12829	11898	14262	9793
Mineral and carbonated waters, unsweetened, 1000 liters	46573	58305	54270	70286	56062
Natural mineral waters, non-carbonated, 1000 liters	49984	46666	64464	70872	74759
Other non-alcoholic beverages, 1000 liters	114171	139577	126823	154261	153849
Cigarettes, cigars, cigarillos, and similar products made from tobacco or tobacco substitutes, million pieces	28171	28197	32817	40332	42163

According to the 2024 structure data of the manufacturing industry by the Statistical Committee of the Republic of Armenia, in percentage terms within the total, food production accounts for 31.4%, beverage production for 10.3%, and tobacco product manufacturing for 8.8% [10].

The data of the Statistical Committee show that in recent years food production in our country has experienced stable growth (Table 2).

Table 2

Indices of Production Volume by Types of Economic Activity Compared to the Previous Year, % [11]

Manufacturing Industry and Sub-sectors	2020	2021	2022	2023	2024
Total Industry	100,6	103,7	108,7	106,4	104,8
Manufacturing Industry	98,2	103,9	115,6	108,8	107,1
Food Production	101,9	103,9	107,4	96,6	104,2
Beverage Production	89,8	119,3	101,6	99,9	98,5
Tobacco Product Manufacturing	81,8	84,7	107,8	116,8	112,2

Despite the recorded growth, the data presented in Table 3 below show that regarding essential food products such as wheat, vegetable oil, sugar, and certain types of meat products, there is a problem of self-sufficiency.

Table 3

Self-Sufficiency of Essential Food Products, %, 2020–2024 [12]

	2020	2021	2022	2023	2024
Wheat	24,4	23,2	24,4	27,9	22,8
Potatoes	101,1	111,7	98,4	99,2	106,2
Vegetables and melons/gourds	103,9	105,6	102,0	97,4	99,6
Fruits and berries	98,2	114,4	102,0	103,1	100,5
Grapes	108,0	106,7	106,6	106,6	103,7
Vegetable oil	0,9	0,6	0,1	0,0	0,0
Sugar	38,0	33,9	91,2	42,8	55,0
Eggs	100,3	98,8	99,2	98,8	98,9
Milk	82,0	87,7	83,4	80,2	78,6
Beef	87,3	92,2	89,7	90,7	88,0
Pork	45,1	53,2	47,3	48,0	49,7
Poultry meat	23,9	26,7	25,3	25,4	26,0
Fish	148,4	143,7	148,0	136,8	118,8

Negative changes in wheat self-sufficiency in the Republic of Armenia are mainly a result of the reduction in wheat sown areas. Despite the widely accepted approach that it is necessary to increase soil fertility and use high-yield wheat varieties, the expansion of wheat cultivation areas remains a priority. The increase in wheat sown areas should be combined with addressing the issue of uncultivated and inefficiently used arable land [13].

The low level of wheat self-sufficiency and dependence on imports indicate the strategic importance of increasing wheat production volumes, which can be achieved through improving yield levels [14].

Since our country faces the problem of closed borders and most imports are carried out through the Lars checkpoint, which is often closed during winter months, especially for freight transport, and sometimes experiences disruptions during other periods of the year, this leads to delays in the import of goods. Therefore, ensuring the supply of raw materials to the food industry through domestic production becomes highly important.

A considerable amount of food is imported into the Republic of Armenia, which helps address threats to food security. Large quantities of beef, pork, poultry meat, wheat, and milk powder are imported.

Table 4

Food Products Imported to the Republic of Armenia, 2020–2024, tones [15]

	2020	2021	2022	2023	2024
Wheat	350310.7	272463.4	364693,8	343562,3	316009,2
Flour	20973,9	20959,6	31546,0	65493,0	42296,3
Rice	11110,9	8917,3	11644,5	9882,1	10072,1
Pasta	14043,3	10830,0	15027,1	14379,1	12400,4
Sugar	43396,6	47724,4	5648,1	36778,4	40347,8
Vegetable oil	30615,8	27189,6	33903,6	33467,6	32575,4
Eggs	30,4	180,6	277,4	387,8	278,7
Poultry meat	34142,3	38454,9	38362,2	38783,4	40885,8
Beef	3882,5	4583,8	4978,4	4503,4	5626,2
Pork	5920,0	9807,8	11390,8	11123,6	13010,9
Milk (all types)	9421,7	9504,9	22275,6	16049,0	17778,5
Butter	4575,3	2590,5	4291,4	4393,7	4285,4
Cheese	1521,4	1782,7	2636,3	2966,4	3100,1
Vegetables	29378,8	33667,8	58951,3	45920,2	44627,6
of which: potatoes	2746,0	3430,8	5799,2	7752,8	1468,0
Fruits	95918,8	103183,4	102382,1	94804,8	105802,6
of which: grapes	2032,7	894,3	1213,6	784,2	1881,2
Melon crops	4956,5	6306,1	8030,0	9049,7	8900,5

The food industry addresses food security issues while simultaneously ensuring added value and creating new jobs.

Table 5

Average Annual Number of Employees by Types of Economic Activity (1,000 persons), [16]

Manufacturing Industry and Sub-sectors	2020	2021	2022	2023	2024
Total Industry	104,4	104,1	104,8	110,8	111,0
Manufacturing Industry	70,2	71,2	71,8	78,6	78,3
Food Production	21,4	20,8	19,6	21,4	22,1
Beverage Production	7,5	7,6	7,5	7,7	7,7
Tobacco Product Manufacturing	4,3	4,1	4,2	4,6	4,8

The data of Table 5 show that in all branches of the manufacturing industry, an increase in the number of jobs has been recorded. The Armenian food industry market is saturated with producing organizations, and the competitive struggle between them contributes to the emergence of environmental, managerial, and social issues, the solutions of which pursue not only narrow corporate economic interests but also public interests [17].

The development of the food safety sector is one of the important processes of the policy implemented in the agricultural sector of the RA economy, the aim of which is to provide consumers with high-quality and safe food products and ensure food security. The food production sector is directly related to the agricultural sector, the inevitable risks of which have an impact on the efficiency of the food industry.

The state implements targeted agricultural development programs. An important precondition for the development of the food industry is the use of domestic raw materials, which will ensure economic efficiency and contribute to improving food quality [18].

The consumption of food industry products is also influenced by fluctuations in the social condition of the population. Due to insufficient financial resources, consumers do not prioritize the purchase of safer food. Small and medium-sized enterprises engaged in food production may be subject to fines following inspections, while some rural households process milk under home conditions and sell products on the streets, posing a threat to public health. Food safety must be ensured regardless of the place of production, supply, storage, and consumption. State financial resources and capacities should be directed toward solving the above-mentioned problems, ensuring the production of safe food.

There is a need to develop a system through which scientifically grounded information can be transferred to industrial processing enterprises and regulatory and supervisory bodies, so that they can use this information for the purpose of producing safe food [19].

For food safety, it is important to improve legislation in the sector, ensure control at all stages of the food industry, and implement a continuous training system for specialists, among other measures. Some food-producing and processing enterprises in Armenia plan to export their products abroad. In this case, exported goods must comply with international standards, which will contribute to the supply of safe food to both international and local markets, protect consumer rights, and build trust in food quality.

Conclusion

The food industry holds an important place in the field of food security and is directly linked to the high-risk agricultural sector. The effectiveness of the food industry also depends on the social condition of the population. Due to insufficient financial resources, consumers do not demand the purchase of safer food. It is important to ensure the population is provided not only with sufficient quantity but also with high-quality food products, which will ensure people's health and intellectual strength. An important prerequisite for the development of the food industry is the use of domestic raw materials, which will support the agricultural sector and ensure economic efficiency.

The food industry addresses food security issues while simultaneously providing added value and creating new jobs.

As a result of the development of the food industry, we observe:

• an increase in the level of self-sufficiency, especially in strategically important goods that depend on imports,

• diversification of local production through increased processing of domestic raw materials,

• expansion of export potential, which, under conditions of a small market, will contribute to the stability of local producers.

These measures will contribute to the stability and development of the economy, agriculture, and the food industry, and will increase the population's quality of life and level of well-being.

Conflict of Interest

The authors declare no conflicts of interest.

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CALORIC INSUFFICIENCY IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT (USING THE EXAMPLE OF ARMENIA)

Alvard Matinyan[1,2,*], Stella Gabrielyan[2]
[1] M. Kotanyan Institute of Economics
[2]Armenian National Agrarian University, Faculty of Agribusiness and Economics

Abstract: *Despite sufficient global food production, millions of people still go hungry or are undernourished because safe and nutritious food is not available or, more often, affordable. The relevance of the research is conditioned by the need to identify the causes of malnutrition in the Armenian population and ways to mitigate it.*
The aim of this research is to identify the macroeconomic determinants of calorie insufficiency and assess the impact of socio-economic factors on calorie insufficiency in Armenia during the period 2010–2024. For this purpose, the task was set to study the dynamics of calorie deficiency, identify and assess the main factors influencing it, and based on the research results, present priority measures to reduce calorie deficiency.
The research was conducted using Pearson correlation analysis and OLS (ordinary least squares) regression modeling methods. Regression analysis showed that calorie deficiency in Armenia is caused by a number of factors: income inequality, rising food prices, instability of agricultural production, as well as lack of awareness about a healthy diet. Therefore, its reduction requires a comprehensive policy that will include social, economic, and agricultural measures. This will allow strengthening the food security of the population and support the implementation of sustainable development goals.

Keywords*: food security; calorie insufficiency; poverty; income inequality; sustainable development goal-2.*

Alvard Matinyan*
E-mail:
alla_matinyan@yahoo.com

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Introduction

Meeting the food security needs of the population, including during emergencies and martial law, is one of the priorities of the Government of the Republic of Armenia (RA) [1]. In addition to the current geopolitical events, the problem of ensuring food security has become even more acute due to income inequality among the population, fluctuations in food prices, and unequal access to necessary resources. Increasing the level of food security will make it possible to mitigate the consequences of natural, political, security, and other crises, contributing to the socio-economic development of the country. This is also enshrined in the 2nd Sustainable Development Goal (SDG 2) "No Hunger", and in this regard the RA government has committed to ending hunger, ensuring food security, and improving nutrition by 2030 [2]. The level of food insecurity and food security is influenced by a number of factors: income, gender, education, meal frequency, food structure, dependence on imports, food losses, full and efficient use of agricultural resource potential, etc. Food insecurity in the Republic of Armenia is quite high: more than half of the population is at risk of food insecurity. The latest "Food Security and Vulnerability Assessment of the Republic of Armenia" conducted by WFP records that 23 % of the surveyed households are food insecure, and 56 % are at the threshold of food security [3]. This indicates that the majority of the population of the Republic of Armenia is at risk of becoming food insecure in the event of crisis or shock situations, and the relevance of the topic is conditioned by the need to identify realistic ways to solve it.

The purpose of the research is to identify the causes of caloric deficiency in the Republic of Armenia and to substantiate the priority opportunities for increasing the level of food security and food security. To achieve this goal, the following tasks have been set:

- to present the level of caloric deficiency of the population in the Republic of Armenia in 2010-2023,

- to study the dynamics of the main determinants of caloric deficiency in 2010-2023 / the average monthly income of the population of the Republic of Armenia, the structure of consumer spending on food, food prices, poverty, unemployment, inequality levels,
- to identify the regression correlation between caloric deficiency and the main determinants.
- to assess the impact of each factor,
- to present the possibilities for increasing the level of food security in the Republic of Armenia.

Literature Review

The concept of food security originated in the 1970s and has been constantly evolving since then, reflecting its complexity and the difficulty of implementing it in changing political and operational environments. The concept of food security was first proposed in 1974 at the World Food Summit (WFS) and was defined as "the permanent availability at all times of sufficient supplies of basic foodstuffs to meet the sustainable growth of food consumption and to compensate for fluctuations in production and prices" [4]. According to this definition, food insecurity is caused by a lack of quantitative food resources and high international food prices.

In 1983, the concept of ensuring access to available resources was included in the concept, that is, "paying equal attention to both demand and supply: ensuring that all people have both physical and economic access to essential foodstuffs at all times" [5]. The idea behind this concept was that the determinant of food insecurity was not an inadequate supply of food, but inadequate control over food resources.

In 1996, the concept of food security was included and food security was defined as a situation where people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life [6].

Food insecurity, defined as the lack of access to sufficient, safe and nutritious food at all times for an active and healthy life, affects millions of people worldwide [7,8]. Food security is a holistic system that includes the physical availability of food (agricultural production and market conditions), access to food (economic and physical), stability (price and income shocks), and utilization (food security and nutritional knowledge). While people's ability to access food is determined by personal income and food prices, food security can deteriorate due to falling income levels, high food prices and/or food supply shocks.

Food insecurity is a major challenge worldwide. Given the importance of reducing food insecurity, many researchers have attempted to identify the main determinants of food security and food insecurity, focusing on the dimensions of food safety, availability, and accessibility.

V. Stany found that the causes of food insecurity are multiple: education, gender, income, food quantity, and it is necessary to encourage large-scale production through new technologies, access to food, education and finance, strengthening the capacities of farmer organizations, diversification of activities, access to resources by women, and development of agricultural markets for products and inputs [9].

N. Aziz examining the macroeconomic determinants of food insecurity in South Asian countries, concluded that increased production increases malnutrition and that national food access is not sufficient to reduce malnutrition unless poor people also have economic and physical access to food [10].

S. Lin emphasize the importance of the environment in addition to economic determinants and propose healthy dietary scenarios for Asian countries of different status, taking into account environmental impact, calorie intake, and income level [11].

Olufemi-Phillips consider the increase in food prices as the main determinant of food insecurity and propose to control prices and provide subsidies to low-income households to mitigate its impact [12].

There is almost no research on econometric estimates of the determinants of calorie insecurity in the case of Armenia. The data are mainly focused on food consumption statistics, such as the daily bread consumption of the population in Armenia. From this perspective, the research presented will provide an opportunity to examine the level of calorie insecurity of the RA population and identify its main determinants.

Methodology

When assessing the levels of hunger, poverty, and food security, international organizations (FAO, WHO) use the concept of "minimum dietary energy requirement" and have adopted a threshold of 2100 Kcal/day [13], [14]. In the article, to assess the prevalence of malnutrition, we considered the indicator of caloric deficiency (quantitative energy deficiency) and took as a criterion the proportion of the population consuming less than 2100 Kcal (%).

Table 1

Baseline data on calorie deficiency and factors influencing it in the Republic of Armenia*

Years	The proportion of the population consuming less than 2100 Kcal, (%)	real monthly income, thousand drams	food price index (including alcoholic beverages and tobacco) (%)	Poverty level, (%)	unemployment rate, (%)	Gini coefficient /by income /
	Y	X_1	X_2	X_3	X_4	X_5
2010	59.7	94872.5	109.4	35.8	19	0.362
2011	55.5	100364.0	112.3	35.0	18.4	0.371
2012	52.9	110295.0	102.0	32.4	17.3	0.372
2013	59.2	138491.0	105.8	320	16.2	0.372
2014	60.2	153961.0	101.7	30.0	17.6	0.373
2015	60.8	165491.8	103.1	29.8	18.5	0.374
2016	62.9	176921.9	96.7	29.4	18.0	0.375
2017	68.9	176056.4	104.0	25.7	17.8	0.359
2018	56.4	168514.1	102.5	23.5	19.0	0.36
2019	76.6	180150.9	102.1	26.4	18.3	0.381
2020	72.6	187466.4	101.2	27.0	18.2	0.363
2021	68.9	190343.3	111.0	26.5	15.5	0.364
2022	75.2	216920.8	112.5	24.8	13.5	0.352
2023	77.4	264700.0	100.4	23.7	12.4	0.348
2024	73.5	286313.1	98.8	21.7	13.3	0.339

**The table was compiled by the authors based on the data of the Food Security and Poverty and Statistical Yearbook of Armenia for 2010-2025.*

The study was conducted using Pearson correlation analysis and OLS (ordinary least squares) regression modeling methods. In this case, the level of caloric deficiency was considered as a dependent variable, and the independent variables included real monthly income, share of expenditures on food, poverty, unemployment rates, income inequality index, and Gini coefficient. The primary data were taken from the RA Statistics Committee publications for 2010-2024 (Table 1).

Pearson correlation analysis revealed the presence and degree of correlation between caloric deficiency and the above factors. Correlation coefficients were calculated, which can range from 0 to 1. When developing the theoretical framework of the main regression model, the causal effects of each variable on each other were taken into account. The model allowed us to quantitatively understand which factors had the most significant impact on the level of caloric deficiency. The initial model looks like this:

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \beta_4 X_{4t} + \beta_5 X_{5t} + \varepsilon t \quad (1)$$

Where:

Y_t – dependent variable,

X_{it} – independent variables,

β_0 – free term reflecting unobserved heterogeneity,

β_1……..β_5 – independent variables included in the study (it is expected that $\beta_1>0$, and the coefficients β_3, β_4 and β_5 will have a negative sign)

εt – random error.

Analysis

As 2030 approaches, the challenges to achieving Sustainable Development Goal 2 (SDG 2) to end hunger, improve food security and nutrition, and promote sustainable agriculture remain unaddressed, exacerbated by extreme weather events, the COVID-19 pandemic, soaring food prices, and geopolitical disruptions. These crises have raised hunger and food insecurity levels above pre-2015 levels,

disproportionately affecting low-income populations and threatening other development goals such as poverty reduction and health.

Armenia is not immune to this situation. According to the Statistical Committee, the share of the population consuming less than 2100 Kcal in 2024 was 73.5%, which increased by 13.8 percentage points compared to 2010. In order to identify the causes of caloric deficiency in the Republic of Armenia, a Pearson correlation matrix analysis was performed. It also made it possible to assess the correlation of macroeconomic indicators and identify possible multicollinearity between independent variables (Table 2).

The results of the analysis showed that there are both strong, medium and weak relationships between the variables included in the studied system. The strongest positive relationship is with the real income factor (X_1) (r=0.802). This indicates that this factor can be one of the important determinants of the phenomenon under study. A strong, but negative correlation was observed with the poverty rate (X_3) (r=-0.702), and the relationship with the unemployment rate (X_4) and the income inequality index (X_5) is relatively weak and insignificant, r=-0.601 and r=-0.478, respectively. As for the relationship between the consumer price index (X_2) and caloric deficiency, it does not have a significant linear effect: r=-0.122.

Table 2

Pearson correlation matrix

	Y	*X_1*	*X_2*	*X_3*	*X_4*	*X_5*
Y	1					
X_1	0.8016026	1				
X_2	-0.122489	-0.3811659	1			
X_3	-0.701967	-0.8938357	0.3565606	1		
X_4	-0.601369	-0.7661795	-0.0163309	0.5500551	1	
X_5	-0.478457	-0.7003924	-0.004267	0.6138993	0.7141924	1

The calculation was made based on the data in Table 1.

The correlation between independent variables was also investigated. It was found that: there is a very strong negative relationship between real income (X_1) and poverty (X_3) r=-0.894, and the relationship between real income (X_1) and unemployment (X_4) is strong and negative: r=-0.766. This indicates a high risk of multicollinearity. There is a strong and positive relationship between unemployment (X_4) and income inequality (X_5) r=0.714. There are positive relationships of medium strength between poverty and unemployment, as well as poverty and income inequality, r=0.55 and r=0.614, respectively.

The results obtained show that caloric deficiency in the Republic of Armenia is caused by several important factors that affect in different directions. If the size of real income acts as a stimulating factor, then the food price index, poverty and unemployment levels exacerbate caloric deficiency.

The results of the multiple linear regression model estimation using the OLS method are presented in Table 3.

The obtained results indicate a close relationship between the phenomena under study (R=0.865), with about 75% of the variation in the level of caloric deficiency being due to the variation in the independent variables included in the model.

In the presented analysis, F =5.34, F significance =0.015<0.05, therefore the model is statistically significant and the combination of independent variables explains the variations in the dependent variable in a statistically significant way.

Now build a regression model based on the data in Table 3

$$Y_t = -156{,}9356 + 0{,}0002483X_1 + 0{,}6858626X_2 + 0{,}5004911X_3 + 1{,}1254357X_4 + 20447019X_5 (2)$$

The calculation results show that the real income of the population has the most pronounced effect on caloric deficiency (β=0.0002483) and with 95% confidence we can claim that when increasing real income by one thousand drams, the proportion of the population consuming less than 2100 kcal will increase by 0.0002483 percentage points. In the case of other factors, although a positive effect is observed, they are not statistically significant, since p>0.05.

The summary results of the study are:

1. Rising food prices have a positive impact on calorie insufficiency, exacerbating the problem of food accessibility.
2. Poverty and unemployment levels contribute to increasing calorie insufficiency.
3. Income inequality limits the social outcomes of economic growth.
4. Real income growth alone is not sufficient to address calorie insufficiency.

Table 3*

Results of the multiple linear regression model estimation

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.8647152
R Square	0.7477323
Adjusted R Square	0.6075836
Standard Error	5.2090867
Observations	15

ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	5	723.85274	144.77055	5.335278	0.0148933	
Residual	9	244.21126	27.134584			
Total	14	968.064				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-156.9356	111.80376	-1.4036702	0.1939676	-409.85327	95.982068
X_1	0.0002483	0.0001011	2.4562532	0.0363816	1.962E-05	0.0004769
X_2	0.6858626	0.3823701	1.7937138	0.1064441	-0.1791188	1.5508439
X_3	0.5004911	0.8633451	0.5797116	0.5763311	-1.4525312	2.4535135
X_4	1.1254357	1.4025795	0.8024042	0.4429909	-2.0474195	4.2982909
X_5	204.47019	192.79703	1.0605464	0.3165264	-231.66699	640.60737

**The calculation was made based on the data in Table 1.*

Conclusion

Caloric deficiency is caused by a number of factors: income inequality, rising food prices, high levels of poverty and unemployment, instability of agricultural production, as well as lack of awareness about healthy eating. Therefore, it is necessary to develop a system of social, economic and agricultural measures to reduce it.

The priority areas for reducing calorie deficiency are:

1. Stabilizing agriculture - for this it is necessary to introduce agricultural technologies that will withstand climate change, ensure effective management of water resources, expand farms and create cooperatives, stimulate local production with subsidies or affordable loans, and reduce dependence on imports.
2. Price stability and control - this will make it possible to increase the physical and economic accessibility of food products. For this, it is necessary to develop measures that will contribute to increasing the supply of food and stabilizing prices. For example, state support programs should encourage agricultural producers to develop logistics systems and storage infrastructure.
3. Increasing the purchasing power of the population – it is necessary to develop measures that will ensure the reduction of poverty levels and income inequality. For example, create jobs in rural communities, expand social programs, create targeted food aid funds for vulnerable groups, periodically review pensions and social benefits in line with changes in food prices, and establish a system of food benefits for poor families

Conflict of Interest
The authors declare no conflicts of interest.
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TAX COLLECTION KEY ISSUES AND ITS SOLUTION NECESSITY IN ARMENIA

Mher Frangulyan[1,*], Kristine Sahakyan[2]
[1] European University of Armenia (EUA), https://orcid.org/0000-0002-4676-1943
[2] Armenian National Agrarian University (ANAU), https://orcid.org/0009-0006-1929-8339

Abstract: *The modern tax system in Armenia was established in 1992, has gone through several stages of development, and is currently being continuously improved and reformed. In this regard, the tax authority of Armenia (the RA State Revenue Service) has set its mission in the area of tax service as ensuring the collection of tax revenues for the State Budget of the Republic of Armenia. In this case, the tax authority of Armenia, in its five-year strategic plans, has set and continues to set goals aimed at improving tax collection technologies. In this context, the application of modern tax collection technologies is one of the most important components in establishing an efficient tax system, endowed with urgency and timeliness, which accounts for the topic's relevance.*

In this context, it is noteworthy that there are numerous scientific studies in Armenia on the formation of an effective tax system. However, the vast majority of them address the proper definition of the tax burden and the improvement of tax administration. In other words, from the perspective of collecting a larger amount of taxes, scientific research has primarily examined possible changes in the tax burden and reforms to tax administration tools.

As a result, the obstacles and problems that arise in the tax collection process in Armenia have been less studied. In this regard, the subject of this article is the aforementioned problems, which have been classified into four main groups and formulated as tax collection challenges, representing the scientific novelty of the article

The purpose of this article is to identify the primary issues with the tax collection technologies used in Armenia and to propose modern solutions for their resolution, which will contribute not only to effective tax collection but also to the enhancement of the tax system's efficiency. To achieve the goal set forth in the article, a qualitative assessment of tax collection technologies was conducted to identify the causes of their unreliability and the potential consequences.

As a result, proposals have been put forward based on resolving the identified fundamental problems in taxation through the development of mechanisms that are aimed at addressing these problems.

Keywords: *taxation, tax system, modern technologies, improvement of the tax system, effective tax system.*

Mher Frangulyan*
E-mail:
mherfrangulyan1987@gmail.com

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Introduction

Speaking of tax collection technologies, it becomes clear that they include the calculation of taxes, the determination of tax liabilities, the payment of taxes by taxpayers, and the establishment of tax control over them, methods and forms of applying remedies, which not only differ in various countries but also undergo periodic changes within the same country over time, with the aim of adapting them to the challenges of the day.

It is characteristic that the efficiency of any country's tax system depends on the application of tax collection technologies. The more it is possible to collect tax revenues with the fewest resources, the more targeted the country's tax system will be and the more it will ensure the collection of the tax revenues planned in the state budget.

The establishment of such an efficient tax system is a top economic challenge and priority in the Republic of Armenia, based on the fact that tax revenues account for approximately 95% of the country's state

budget. By setting the goal of establishing an effective tax system in Armenia, the article highlights the necessity of applying modern tax collection technologies and proposes a number of issues:

- ✓ To study the evolution of tax collection technologies in Armenia,
- ✓ To analyze the tax collection technologies applied in Armenia since its independence.
- ✓ Identify the reasons for the inefficiency of currently operating tax collection technologies in the Republic of Armenia and the existing key problems.
- ✓ Justify the necessity of applying modern tax collection technologies.
- ✓ Outline the directions for the application of modern tax collection technologies.

Literature Review

The issues of taxation and tax administration, as well as the mechanisms for their improvement and enhancement, have always been studied by numerous Armenian and international researchers. And although, in the context of modern technological advancement, the role of such studies has grown and more and more researchers are turning to modern tax collection technologies, nevertheless The tax system of the Republic of Armenia has its own unique characteristics, and research on it is limited by the opportunities provided by Armenia's tax legislation within the country. Therefore, the works of foreign and international researchers, no matter how much they offer scientific novelty from the perspective of forming an effective tax system, do not address the tax system of the Republic of Armenia and require additional research for their implementation in Armenia due to the factor of national specificity.

Based on the above, the fundamental issues of tax administration in Armenia have been studied in the works of Armenian researchers V. Bostanjyan, V. Harutyunyan, T. Harutyunyan, K. Baghdasaryan, and others [1][2][3][4][5]. In particular, the issues of improving tax administration and increasing the effectiveness of tax policy were discussed in the works of V. Bostanjyan and T. Harutyunyan, where the authors substantiate the link between the simplicity and stability of tax legislation and the efficiency of the tax system, proposing the optimization of the tax burden as a solution. However, the authors have not addressed the obstacles and problems in the tax legislation, which, even under conditions of tax law simplicity and optimal tax burden, in some cases compel and in others allow taxpayers to enter the shadow economy. In this context, it is noteworthy that the problems in the tax legislation relate not only to the tax burden and tax administration, but also to the registration of taxpayers, the submission of reports, the payment of taxes, and other mechanisms of the tax system.

V. Harutyunyan too addressed the key issues of an effective tax system in the Republic of Armenia. The author argues in the study that the yield-neutral tax system should reduce taxpayer costs and ensure predictability, However, the author did not address the problems of disproportionate tax administration, under which it is impossible to reduce taxpayer costs and ensure effective tax administration. K. Baghdasaryan has also conducted research from the perspective of forming an effective tax system, in his work "Problems of Management and Evaluation of Taxation Mechanisms" co-authored works and "Methods for Assessing the Shadow Economy and Approaches for Their Implementation in the Republic of Armenia" argue that the efficiency of the tax system is linked to the "tolerable" tax burden and the indicator of shadow economy reduction [6]. However, it has not addressed the causes of the emergence of the shadow economy and the problems under which the tax burden is "unbearable" for taxpayers [7]. And although other Armenian researchers have studied the fundamentals of an effective tax system, nevertheless, in this regard, the issues of tax collection in Armenia as a function of tax system management have been less researched.

The fundamental problems in the tax collection process that hinder the effective collection of taxes in the Republic of Armenia have been insufficiently studied, resulting in lower-than-expected outcomes despite the state's expenditures for tax administration. The latter have formed the basis of the article's research, aiming not only to identify the main issues in the tax collection process but also to classify them and, by proposing solutions, coordinate the key directions for establishing an effective tax system in Armenia.

For this reason, in addition to the studies by the aforementioned authors, the tax legislation of Armenia also served as a basis for the analysis conducted in this article. The actual acts and documents related to the management of the RA tax system, and the reports published by the RA tax authority.

Methodology

Within the framework of this study, descriptive, problem identification, causal analysis, and qualitative assessment methods were applied. In particular, the evolution of tax collection mechanisms in Armenia has been presented using the descriptive method. To this end, the history of the State Revenue Committee of

Armenia since its independence was studied, as well as the strategies developed and implemented by the tax authority during that period. annual activity reports, and the implemented tax collection mechanisms.

Based on the analysis results and using the qualitative assessment method for identifying causal relationships, the main problems hindering effective tax collection in Armenia were identified and classified into separate groups, and recommendations were presented for them.

Analysis

As with any phenomenon, the study of tax collection technologies in Armenia first and foremost involves an investigation of its evolution, which will make it possible to understand how these technologies were formed and what dynamic changes they underwent over time as they faced various obstacles. In this context, it can be confidently asserted that the need to develop tax collection technologies arose in the years following Armenia's independence, when the idea of having a state made the establishment of a tax system a top priority. It was logical that at that time it was already extremely important to convey to the citizens and businessmen of an independent and war-torn country the idea that paying taxes was as important and vital to the country's victory in the war, without which the state simply cannot carry out its functions. And although it was difficult, the newly formed tax system succeeded in introducing the first tax collection technology: a culture of paying taxes.

From this point on, as the tax system developed, tax collection technologies have periodically evolved and been refined, forming the following successive stages of tax collection technology:

- In the first phase, legislation aimed at tax collection was established to effectively organize tax collection. In 1997, the Law of the Republic of Armenia "On Taxes" was adopted [13], followed by laws on individual types of taxes. In May 1997, the Law of the Republic of Armenia "On Value Added Tax" was adopted [14], followed in September by the Law "On Corporate Profit Tax" [15] and in December by the Law "On Income Tax [16]." In 2000, the Law on Simplified Tax was adopted, and so on [17]. With the establishment of the legislative framework, the scope of taxpayers was defined, and the obligation to pay taxes was legally formalized, which, according to the Law on Taxes of the Republic of Armenia, provided that the taxpayer is obligated to independently calculate the amounts of taxes prescribed by law and to pay them into the state budget. The fulfillment of this obligation required the taxpayer to independently calculate and submit reports, the accuracy of which was subject to verification by the tax authority. Calculation and reporting were carried out on paper, and their processing required a long period of time and a large amount of labor resources. The presence of inaccuracies caused by subjective factors not only complicated the tax collection process but also affected the operational efficiency and effectiveness of the tax administration.
- In Phase 2, to improve existing technologies, https://file-online.taxservice.am and «e-invoicing» were implemented as an electronic system, which aimed to reduce the time spent by taxpayers on reporting and increase the efficiency of tax control by the tax administration. It was logical that in order to avoid fraudsters on the electronic platform and to protect the tax confidentiality of each taxpayer, the aforementioned electronic programs should have been built with high-security technologies, which overloaded the server system when numerous taxpayers submitted their returns simultaneously, causing software malfunctions.
- In the third phase of tax legislation reform, in 2016, the separate laws on individual taxes were consolidated into a single comprehensive document: the Tax Code of the Republic of Armenia. In this regard, the development of a single, comprehensive document was intended to consolidate the legislative provisions and procedures related to a taxpayer's activities and governing their relationship with the tax authority. However, in contrast, the ambiguities and poor readability of the tax code increased the likelihood of taxpayers committing legal violations and underscored the need to improve tax administration [3]. As a result, over the years, the amounts of taxes paid by taxpayers became overpayments due to the use of various technologies, which were subject to refund from the state budget, thereby jeopardizing its security.
- In Phase 4, a new tax payment system was introduced to further avoid overpayments subject to refund from the state budget. Under this system, payments made by the taxpayer began to be accumulated in a single account for taxes and were to be transferred to the state budget only when a tax liability was determined based on the taxpayer's submitted report. However, in all cases, when, in compliance with the Tax Code of the Republic of Armenia, a taxpayer amends the report they submitted within three years after filing and reduces their tax liability, the tax collection process becomes chaotic and unmanageable. In particular, in the context of numerous electronic reports, establishing controls over

report corrections and managing unpredictable corrections requires not only additional time but also additional labor resources, which, on the one hand, can create chaos and on the other hand, reduce the efficiency of the tax collection process.

- In Phase 5, tax administration was improved to prevent potential violations by taxpayers during the tax collection process [4]. The tax authority developed a strategy aimed at improving tax administration and tax reforms, which set five key objectives for improving tax administration for the years 2021-2025 [9].
    - Improving management systems and providing digital services to taxpayers.
    - Increasing the efficiency of tax administration, increasing revenue, and reducing the shadow economy.
    - Modernizing and building infrastructure.
    - Improving the level of dialogue with the public.
    - Implementing a modern human resources management system.

However, from the aforementioned objectives aimed at improving tax administration, it can be inferred that the centerpiece of the tax authority's strategy is to hold taxpayers accountable for statutory violations resulting from tax administration, which very often, according to the Laffer curve, has a counterproductive and negative effect on both the tax collection process and GDP [2]. The latter is justified by the high shadow economy indicator. The most up-to-date and comprehensive information on Armenia's shadow economy is presented in the International Monetary Fund's (IMF) 2018 report "Shadow Economies Around the World: What Did We Learn Over the Last 20 Years?".

Table 1

RA Economic and Tax Indicators (2020-2025)[1]

Indicators	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Gross Domestic Product (GDP)	6,181.9	6,991.8	8,501.4	9,492.5	10,210.0	11,317.5
Tax Revenues and State Duties	1,387.1	1,586.9	1,926.0	2,221.9	2,390.0	2,725.2
Tax-to-GDP Ratio %	**22.4**	**22.7**	**22.7**	**23.4**	**23.4**	**24.08**

Although it is clear from the table that the tax-to-GDP ratio increased from 22.04 percent to 24.08 percent compared to 2020, this increase is due to two factors: First, as the table shows, GDP has increased by 83 percent compared to 2020, which, according to the laws of macroeconomics, should have increased tax revenue by the same, and even more, multiple times due to the multiplier effect.

Second, in 2023-2025, changes were made to Armenia's tax legislation, as a result of which the tax burden on turnover tax payers was doubled and the penalties for tax violations were tightened. In other words, a simple calculation shows that this increase in taxes is not the result of reducing the shadow economy, but rather of GDP growth and an increase in the tax burden. This phenomenon is most apparent when we examine the dynamic changes in taxes by individual tax types.

Table 2

Armenian state taxes by individual tax types, 2020-2025, (expressed in billion AMD)[2]

Tax Type / Revenue Stream	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Value Added Tax (VAT)	486.2	536.8	652.8	741.0	755.6	**914.3**
Income Tax	425.8	455.5	509.3	545.9	649.9	**726.9**
Profit Tax	158.4	165.7	251.2	344.2	358.5	**392.0**
Excise Tax	120.3	114.7	126.9	148.5	155.0	**172.5**
Customs Duties	81.1	112.5	80.6	120.4	145.2	**162.1**
Turnover Tax	29.5	32.8	41.5	45.2	48.0	**54.2**
Other Taxes & State Duties	85.8	168.9	263.7	266.7	277.8	**303.2**
TOTAL TAXES AND DUTIES	**1,387.1**	**1,586.9**	**1,926.0**	**2,221.9**	**2,390.0**	**2,725.2**

[1] The table was compiled by the authors using the annual reports of the State Revenue Committee of Armenia.

[2] Source: official website of the RA State Revenue Committee, https://src.am

According to the published document, the average shadow economy indicator in the Republic of Armenia for 1991–2015 was estimated at 42, 6%: And although according to IMF publications the shadow economy rate declined after 2015 and stood at around 36 percent in 2015, Nevertheless, such a high figure points to the problems in the tax collection process that force taxpayers into the shadow economy.

However, considering that a lower shadow economy rate of 20% was published by the competent tax authority of the Republic of Armenia in 2025, let's analyze the results of the RA State Revenue Committee's activities from 2020 to 2025.

The table clearly shows that while the total tax revenue increased, not all tax types grew proportionally. In particular, reducing the shadow economy implies primarily registering unregistered workers and an increase in realized turnover. Considering that under Armenian legislation, a taxpayer begins to pay VAT when their turnover exceeds 115 million drams, it is assumed that as the shadow economy has shrunk, VAT should have also increased accordingly. whose rate is 20 percent, than profit tax, whose rate is 18 percent.

However, in this case, the increase in VAT is not only smaller than the increase in corporate income tax, but also corresponds to the growth in GDP. In the event of registering previously unregistered workers, thereby increasing the number of employees and the average wage and reducing the shadow economy, income tax, in accordance with Armenian legislation, should have increased.

Overall, although it can be argued that 2020 -2025 tax growth is the result of GDP growth, nevertheless, let's consider what expenses the State Revenue Committee of Armenia has incurred for the increase in these tax revenues in terms of applying tax administration tools.

Table 3

Number of Tax Audits and Investigations in RA, 2020-2025 ***(figures expressed in units/counts)***

Audit / Control Type	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
1. Comprehensive Tax Audits	14 800	16 500	12 200	10 800	980	**910**
2. Thematic & Operational Audits	8 240	9 850	11 400	13 100	14 800	**11 540**
3. Desk (Cameral) Audits	18 500	22 400	26 100	29 800	34 200	**38 600**

The table clearly shows that tax administration has almost doubled in 2025 compared to 2020. In this regard, the efficiency of the tax system's management has not undergone a significant change, as tax revenues have also increased by a similar multiple, which is mainly the result of GDP or economic growth.

The study and analysis of the aforementioned tax collection technologies show that although their evolution over time has improved the mechanisms for collecting taxes, but the technologies in use in the tax collection process in Armenia have a number of problems that negatively affect the efficiency of the tax system, becoming causes of tax collection inefficiency. Specifically, such problems include:

- ✓ **The problem of unnecessary complexity in tax accounting:** The tax registration procedures are currently defined by the Tax Code of the Republic of Armenia, which very often places the taxpayer in a dilemma, frequently forcing them to break the law when complying with it becomes technically impossible. In particular, the requirement to submit legally prescribed adjusted reports when a taxpayer declares turnover that was not previously reported in the submitted documents creates a dilemma and complicates future tax accounting. In another case, the acquisition of goods without documentation by a trader subject to turnover tax entails payment of the tax at a rate of 10 percent, However, failure to comply with documentation requirements under tax control under the same legislation entails a 20 percent penalty, etc.
- ✓ **Problem of the electronic reporting burden:** The principle of the taxpayer's self-assessment and filing of returns implies that the results of any of the taxpayer's activities must be declared in the prescribed manner, for which the taxpayer submits a report. The variety and deadlines of reports place a burden not only on the taxpayer but also on the entire tax system.
- ✓ **Problem of unreliable tax collection:** The current tax collection system stipulates that the taxpayer must pay the tax within the period set for filing the tax return, after submitting the return. Under this mechanism, the taxpayer can easily postpone payment of the tax liability, in some cases not paying it at all. Over time, the tax liability becomes unmanageable, growing larger as the taxpayer continues to earn income and file returns, and at some point, is declared bankrupt due to substantial tax obligations.
- ✓ **The problem of disproportion in tax administration:** A thorough analysis of the Tax Code of the Republic of Armenia shows that the purpose of applying tax administration tools is to hold taxpayers

liable through the imposition of surcharges and fines. In this regard, there are many instances in which the imposed penalty is disproportionate to the infraction committed, especially when the taxpayer's operational characteristics are taken into account. It should be noted that the fine is an additional expense for the taxpayer, and in order to recoup it, the taxpayer is driven to seek new ways to go underground.

Conclusion

Based on the research conducted in the article, the application of modern tax collection technologies is proposed to address the aforementioned issues by enhancing those already in existence. Specifically:

- In order to address the problem of unnecessary complexity in tax accounting, we propose amending the Tax Code of the Republic of Armenia by excluding the submission of amended calculation-reports in cases where the figures presented as a result of the amendment do not correspond to reality. At the same time, the changes should be aimed at reviewing all provisions that, at any point in time, may conflict with or complicate the taxpayers' self-declaration process.
- The issues of the burden of electronic reporting and the unreliability of tax collection are interrelated, because the obligation to pay taxes arises when the taxpayer submits a tax return. The unreliability of tax collection arises when taxes are not paid after the return is filed. Therefore, by addressing the burden of electronic reporting, it is also possible to resolve the issue of tax collection. To address the problems of the burden of electronic reporting and the unreliability of tax collection, we propose to reduce the number of calculation reports submitted by taxpayers; Specifically, in cases where the calculation-report is informational or merely a repetition of a previously known indicator, as well as in the declaration of information related to a non-cash transfer transaction, the requirement to submit the report should be eliminated. Instead of filing a report, entrust the calculation of the tax liability and its subsequent collection to the tax agent: to the bank executing the transfer, which, for cashless transfers, including those made through the bank, will automatically withhold the tax amount from the transferred sum and remit it to the budget: providing the taxpayer's information at the time of the transfer, and submitting an annual report on the taxes collected and paid to the budget:

In applying this mechanism, the tax authority is simply relieved of tax oversight over non-cash transactions, delegating the function of collecting the taxes calculated on them to the bank. Naturally, in this case the tax authority can direct all of its administrative tools toward imposing tax controls on cash transactions and collecting the taxes due.

Overall, the application of this mechanism is not intended to make the bank a tax agent, but rather to reduce the volume of reports to be submitted by excluding their submission when the taxable transaction is obvious and the tax due can be collected immediately, thus avoiding the risk of non-payment later. This also reduces the tax authority's scope of supervision, allowing it to focus on transactions where the risk of the shadow economy is high. To address the issue of disproportionate tax administration, we propose to increase the number of administrative tools instead of the fines applied as a result of tax administration, which are aimed at further preventing violations and, as a result, reducing of the shadow economy. In this regard, it would be more effective to spend resources to communicate the idea to each taxpayer that there is no opportunity to operate in the shadow and that it is necessary to fully declare received income and pay taxes, rather than imposing a fine that forces the taxpayer to return to the shadow in order to compensate for it.

Conflict of Interest

The authors declare no conflicts of interest.

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ARTIFICIAL INTELLIGENCE FOR CIRCULAR TRANSFORMATION IN FAST FASHION: SYSTEMATIC REVIEW THROUGH THE 12R FRAMEWORK

Svetlana Ratner[1,*], Lyubov Kondratenko[2]
[1]Department of Economic and Mathematical Modeling, Peoples' Friendship University of Russia (RUDN University)
[2] Laboratory of Management in Technical Systems, Kuban State University

Abstract: *The rapid development of artificial intelligence (AI) creates new opportunities for the circular transformation of fast fashion, yet evidence on its contribution to individual circular-economy strategies remains fragmented. This study applies a systematic literature review (SLR) structured around the 12R framework to identify the principal mechanisms of AI application, compare their distribution across circular strategies, and assess whether reported operational improvements are accompanied by demonstrated environmental effects. Publications were identified through Google Scholar and screened using thematic relevance criteria; journal quartile was subsequently applied as an additional source-selection criterion. The analytical stage combined qualitative content analysis, deductive 12R coding, frequency analysis, and comparative synthesis. The results show a strong concentration of research in R1 Rethink and R2 Reduce, particularly in demand forecasting, personalization, inventory optimization, digital design, and quality control. Later-loop strategies are represented much less frequently in the retrieved corpus. However, this imbalance is interpreted cautiously because the search query did not explicitly enumerate all 12R-specific terms. The review also demonstrates that operational efficiency should not automatically be equated with environmental improvement: only evidence based on measurable changes in waste, resource use, or material flows can substantiate such effects. The study contributes a strategy-level mapping of AI applications and identifies directions for more targeted empirical research.*

Keywords: *artificial intelligence; fast fashion; circular economy; 12R framework; textile industry; systematic literature review; sustainability; digital transformation.*

***Svetlana Ratner**
E-mail:

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Introduction

The fast fashion industry has demonstrated sustained growth in the volume of apparel production and consumption over the past decades, accompanied by systemic negative effects: overproduction, the accumulation of textile waste, high resource intensity of production processes, and a considerable carbon footprint. The linear "production–consumption–disposal" model that underlies the business logic of fast fashion contradicts the goals of sustainable development and calls for alternative approaches to organizing industry processes.

One of the most promising directions for transforming the industry is the transition to the principles of the circular economy, which presumes a closed-loop rather than a linear flow of material resources. The conceptual foundation for systematizing the corresponding strategies is the 12R model (Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Refabricate, Recycle, Recover, Re-mine), which covers the full spectrum of solutions—from preventing excessive consumption to recovering raw materials at the final stages of a product's life cycle.

In parallel, recent years have seen a rapid expansion in the application of artificial intelligence technologies in the fashion and textile industry: from demand-forecasting systems and generative design to computer vision for sorting and recognizing textile materials. AI is increasingly regarded as a tool capable of supporting the industry's transition toward more sustainable and resource-efficient models, including in the

context of marketing—personalizing offers, managing the product life cycle through consumer interaction, and shaping demand consistent with the principles of conscious consumption.

At the same time, the body of research at the intersection of AI and the circular economy in the fashion industry remains fragmented. A significant share of the studies focuses on discrete, predominantly operational applications of the technology—demand forecasting, automated quality control, personalization—whereas deeper strategies for closing the material loop (extending product lifespan, restoration, raw material regeneration) have been studied considerably less. Moreover, the literature insufficiently addresses whether the operational efficiency achieved through AI actually translates into a real reduction in material flows, or whether it may coexist with an increase in consumption intensity driven by the same technologies (in particular, through hyper-personalization and digital marketing).

Thus, despite growing research interest in the application of AI in the fashion industry, the literature lacks a comprehensive, systematized understanding of how specific artificial intelligence technologies relate to the various strategies of the circular economy, and at which stages of the 12R hierarchy their application has been studied most and least extensively. This constitutes a research gap that calls for a systematic analysis of the accumulated scientific literature.

To address this gap, the present study conducts a systematic literature review structured around the following research questions:

RQ1: Which directions and mechanisms of artificial intelligence application in the fast fashion industry are most extensively represented in the scientific literature in relation to the individual strategies of the circular economy (the 12R model)?

RQ2: Which circular economy R-strategies remain the least studied in terms of AI application, and what are the corresponding research gaps?

RQ3: How does the operational efficiency achieved through AI application (demand forecasting, automation, personalization) relate to the actual environmental effect and the prevention of excessive material consumption in the context of the circular transformation of the fashion industry?

The answers to these questions will make it possible not only to systematize existing knowledge on the role of AI in implementing circular economy principles in the fast fashion industry, but also to identify promising directions for further research, including those relevant to marketing practices that shape consumption patterns in the industry.

Methodology

The studies were conducted using methods of sectoral study, descriptive, analytical, and statistical data analysis. As a result, recommendations were presented.

The research was conducted using the systematic literature review (SLR) method. In this design, the structured review, synthesis, coding, and comparison of previous studies constitute the core research method itself; therefore, a separate narrative Literature Review section was not introduced, as it would duplicate the material analyzed within the SLR. PRISMA principles were used to improve the transparency of identification and screening. The scientific methods applied at the analytical stage included qualitative content analysis, deductive categorical coding according to the 12R framework, descriptive frequency analysis, and comparative synthesis. To build the study's information base, a search for scientific publications was conducted in the Google Scholar system. The search strategy was formulated on the basis of the study's main research directions and included a combination of keyword queries: “fast fashion” AND “textile industry” AND “digital technology” AND “AI.” The use of the logical operator AND made it possible to focus the search output on publications simultaneously addressing fast fashion, the textile industry, digital technologies, and artificial intelligence.

The initial search yielded 17,400 results. Given the considerable size of the resulting set, a subsequent thematic screening of the publications was carried out. At this stage, publication titles, keywords, and, where necessary, abstracts and article content were analyzed. From the overall search output, publications corresponding to the study's subject area and revealing the relationship between artificial intelligence and digital technologies on the one hand and the development of fast fashion, the textile industry, sustainable development, resource efficiency, the circular economy, and the digital transformation of the industry on the other were selected. As a result of the thematic selection, a preliminary sample of 186 publications was formed.

The thematic inclusion criteria required a publication to address AI or closely related digital technologies in the fashion/textile context and to contain a substantive link to sustainability, resource efficiency, circular economy, product-life-cycle management, waste prevention, reuse, repair, recovery, recycling, or digital transformation. Records were excluded at this stage when the fashion/textile context was

incidental, when AI/digital technology was not part of the research problem, or when no substantive connection with sustainability or circular transformation could be established.

At the next stage, journal-level bibliometric characteristics were considered using the SCImago Journal Rank (SJR) indicator and the corresponding journal quartile. This criterion was used as an additional source-selection restriction and not as a direct measure of the methodological quality of an individual article.

According to the SCImago methodology, journals are distributed into four quartiles: Q1, Q2, Q3, and Q4, where Q1 corresponds to the top quarter of journals by SJR value, and Q4 to the bottom quarter.

As an additional journal-level selection criterion, a Q1–Q2 threshold was established. Publications from Q3 and Q4 journals were not included in the final 12R analytical corpus. Because journal quartile reflects the relative position and impact of a journal rather than the methodological quality of a particular study, the possibility of selection bias introduced by this restriction is acknowledged as a limitation.

The approximately 17,400 Google Scholar results represent the initial search-engine output rather than the number of full texts individually assessed. Sequential screening of titles, keywords, abstracts and, where necessary, article content produced a preliminary thematic set of 186 publications. After application of the Q1–Q2 journal criterion, 146 publications remained; one publication could not be used for full-text 12R coding, resulting in a final analytical corpus of 145 publications. The 12R content analysis reported below refers to this final corpus.

Results

Bibliographic structure of the sample.

For transparency, the descriptive publication-trend figures below refer to the preliminary bibliographic dataset for which year and journal information had been compiled (183 records), whereas the subsequent 12R content analysis uses the final Q1–Q2 full-text analytical corpus of 145 publications. These two stages serve different purposes and should not be interpreted as the same sample. The descriptive set covers 2020–2026: 14 publications in 2020, 24 in 2021, 34 in 2022, 35 in 2023, 39 in 2024, 35 in 2025, and 2 in 2026. The 2026 value reflects only the portion of that year captured by the search and should not be interpreted as a decline in research interest.

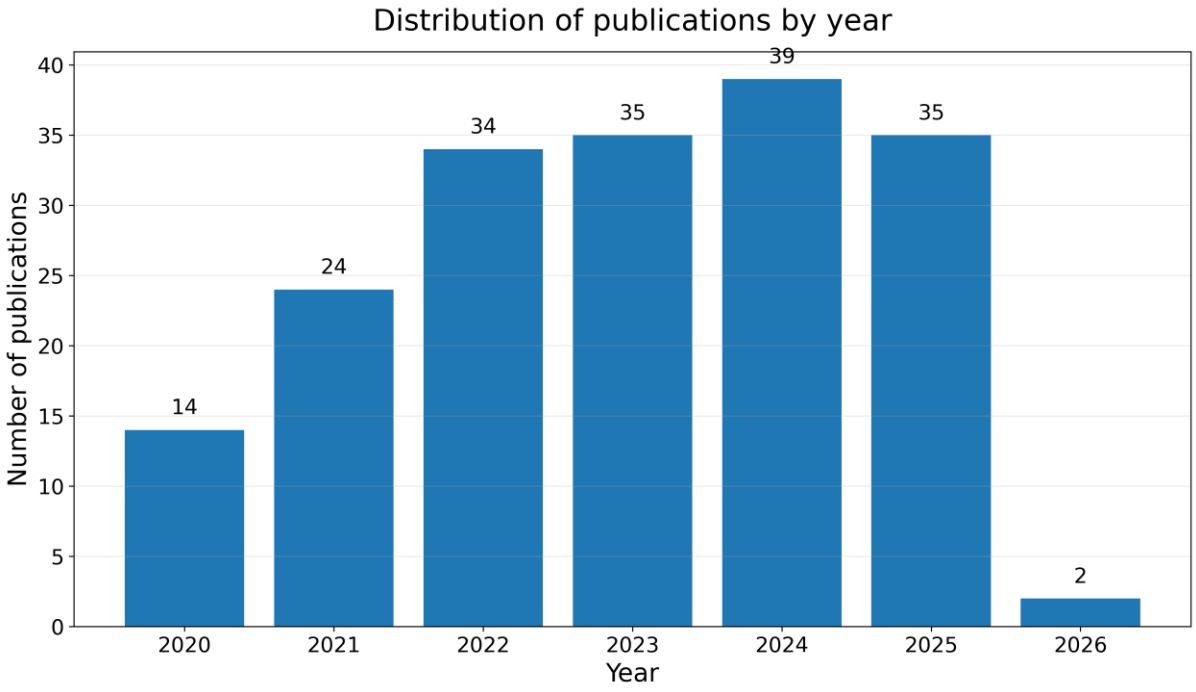

Figure 1. Distribution of publications by year

The observed dynamics indicate the formation of a stable research trend. The most intensive growth is observed in the first half of the 2020s, which coincides with the rapid diffusion of generative AI, computer vision, digital twins, demand-forecasting systems, and intelligent sorting technologies. Recent reviews also record the expansion of AI applications from production forecasting and optimization to garment condition assessment, textile sorting, and support for reuse and recycling.

The distribution of publications by journal is more fragmented (Figure 2). The largest number of papers in the formed sample was published in Sustainability—17. This is followed by the International Journal of Fashion Design, Technology and Education with 5 publications; Fashion and Textiles, the Research Journal of Textile and Apparel, The Journal of The Textile Institute, and Business Strategy and the Environment with 4 publications each. Three papers each are found in Technological Forecasting and Social Change, Textile Research Journal, Current Opinion in Green and Sustainable Chemistry, IEEE Transactions on Engineering Management, and Annals of Operations Research. The remaining leading journals are represented by two publications each.

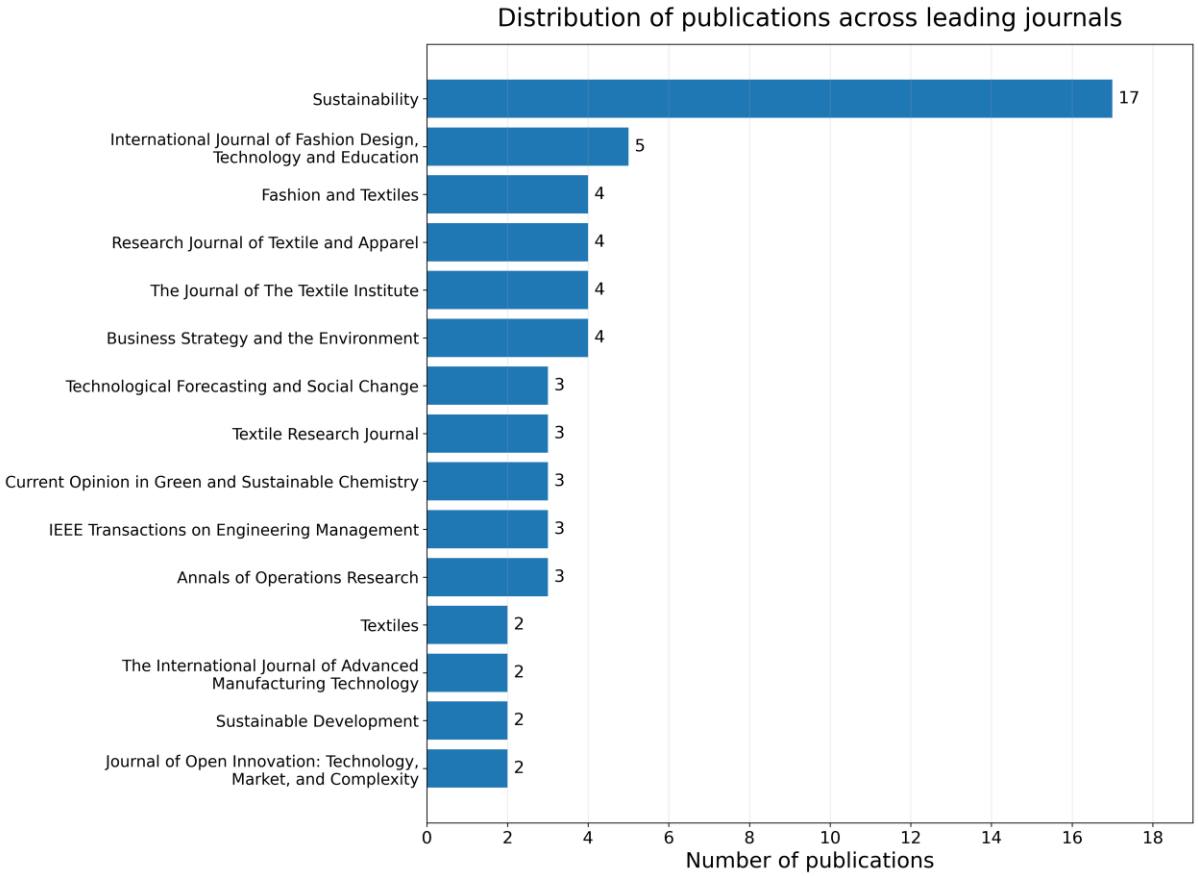

Figure 2. Distribution of publications by leading journals

This structure demonstrates the interdisciplinary nature of the research field. Studies are published simultaneously in journals covering sustainable development, textile technologies, production management, innovation, operations, and digital transformation. This confirms that the application of AI in the circular fashion industry lies at the intersection of engineering-technological and managerial approaches. At the same time, the concentration of publications in Sustainability is notable but not absolute: most of the research is distributed among specialized industry-specific and interdisciplinary journals.

Content analysis results: analysis of the 12R strategies

The systematization of the final analytical corpus in the 12R matrix reveals a pronounced imbalance in representation. R1 Rethink (71 coded publications) and R2 Reduce (64) are the most extensively represented. These are followed by R0 Refuse (18), R3 Reuse (17), R7 Repurpose and R9 Recycle (13 each), R4 Repair (8), R5 Refurbish, R6 Remanufacture, and R11 Re-mine (4 each), and R10 Recover (2). No direct confirmed example was coded for R8 Refabricate. Because one publication may contribute to more than one R-strategy, these frequencies are coding counts and are not expected to sum to the number of publications. The imbalance indicates concentration within the retrieved corpus, but it should not be treated as definitive evidence that research on the less represented strategies is absent.

An important limitation is that the original search query was formulated around fast fashion, textile industry, digital technology, and AI and did not explicitly enumerate every 12R-specific term. Consequently, studies framed primarily through terms such as repair, refurbish, remanufacture, refabricate, recover, or re-

mine may have been under-retrieved. The low frequencies of several R-strategies therefore may reflect both the current orientation of AI research and the boundaries of the search strategy.

R0 Refuse is among the highest-priority circular economy strategies, as it involves preventing the emergence of the need for a material product or for individual resource-intensive operations. In the fashion industry, this logic manifests through digital fashion, virtual design, digital prototypes, and the transfer of part of the interaction with clothing to a virtual environment [1, 2, 3].

Studies on AI-based fashion design demonstrate the possibility of creating and evaluating design options before manufacturing physical samples [4, 5]. Virtual try-on, personalized recommendations, and AI-driven design also reduce the need for certain physical operations at the product selection and development stage [6]. The contribution of AI to Refuse therefore lies primarily in replacing individual material prototypes with digital ones and in preventing unnecessary operations.

However, digitalization alone does not guarantee an absolute environmental effect. Faster development and lower costs of creating new designs can simultaneously increase the number of models and the intensity of consumption. Therefore, the relationship between AI and R0 should be assessed through the actual prevention of material flows rather than merely through the fact of applying a digital technology [7, 8].

R1 Rethink is the most extensively represented strategy in the studied sample. Its specificity lies in changing not a single operation but the very logic of value creation and delivery. Studies of digital transformation show that AI, big data, and digital platforms make it possible to restructure design, forecasting, customer interaction, and supply chain management processes [7, 9, 10, 11].

On-demand production occupies a special place here. Analysis of consumer behavior data and AI-driven forecasting make it possible to bring production volumes closer to actual market demand. This creates an alternative to the traditional “make-to-stock” mass-production model and links Rethink to the subsequent Reduce strategy [7, 8, 14].

AI also supports the transition to service- and platform-based business models. Digital technologies can enable personalization, rental, resale, and the assessment of product condition and residual value—that is, they can change the way consumers obtain value without necessarily increasing primary production [10, 24, 23]. Rethink therefore performs a system-forming function and links digitalization to several subsequent R-strategies.

R2 Reduce ranks second in terms of representation in the sample and is characterized by the most evident causal link between AI and resource efficiency. One of the central mechanisms is demand forecasting. In the study by Dos Santos et al., a Digital Twin combines discrete-event simulation with an artificial intelligence model to support operational planning within a company [13]. Other studies consider AI forecasting as a means of inventory management, increasing production flexibility, and reducing overproduction [8, 14, 10].

The second mechanism is intelligent quality control. Machine and deep learning are applied to image processing and defect detection, making it possible to identify deviations earlier and reduce the volume of defective output and rework [15].

The third mechanism relates to virtual try-on and size recommendations. A more precise match between a product and the buyer's parameters and preferences reduces the uncertainty of online purchasing and potentially decreases returns [10]. Together, these mechanisms form a sequence: data → forecasting/recognition → a more accurate decision → a reduction in unnecessary output, material losses, returns, and logistics operations. R2 is therefore one of the most technologically mature areas of AI application in the context of the circular fashion industry.

Within R3 Reuse, AI primarily reduces the informational and transactional barriers to reuse. Digital rental platforms, the sharing economy, and resale enable the actual period of a product's use to be extended by connecting an already existing product with a new user [10, 17, 16].

Recommendation, visual search, and personalization algorithms can facilitate the selection of items on the secondary market, while condition- and residual-value-assessment models can support decisions on reselling, renting, or returning a product to circulation [11, 24]. The main contribution of AI to Reuse therefore lies not in the physical transformation of the product but in increasing the likelihood of its next use cycle.

R4 Repair and R5 Refurbish are represented considerably less than Rethink and Reduce, although from the standpoint of the circularity hierarchy, extending product lifespan preserves a substantial share of the materials and energy already invested. For Repair, a promising direction is the application of machine learning in product design for repairability, condition diagnostics, and the selection of a restoration method [19, 21, 22].

Refurbish involves a more comprehensive renewal of the product. In this area, AI can be used to assess condition, residual value, and the economic feasibility of restoration. Studies on circular business models emphasize the importance of digital analytics and AI-based residual value assessment for financing and scaling reuse and restoration models [24, 23, 16].

The low representation of these strategies in the retrieved corpus suggests that AI is discussed much more often in connection with sales, forecasting, and production efficiency than with systematic extension of the lifespan of already manufactured clothing. Given the search-strategy limitation noted above, this pattern should be interpreted as an area requiring targeted future investigation rather than as proof of an absolute research gap.

R6 Remanufacture is represented by a limited number of studies. The potential of digital technologies here relates to component identification, suitability assessment, and support for closed-loop supply chains. Studies of circular supply chains show that digital technologies and AI can improve traceability, the coordination of reverse flows, and decision-making regarding the return of resources to production [26, 22, 25].

The evidence base for R7 Repurpose is broader. AI can classify textile waste by composition and properties, thereby helping to select a new use for the material. Spectroscopy technologies combined with machine learning and deep learning, which enable the automatic recognition of textile materials, are particularly important here [27, 8]. In this case, AI converts a heterogeneous waste stream into an informationally described secondary resource, for which a more suitable route—reuse, upcycling, or recycling—can be determined.

For R8 Refabricate, no direct confirmed examples were identified within the retrieved and coded corpus. This finding should be interpreted as non-identification under the present search strategy rather than as evidence that such applications do not exist. Technological preconditions are nevertheless visible: AI-enabled identification and sorting can generate more homogeneous secondary raw-material streams [27, 8], while digital technologies can support closed production loops [4, 25].

Within the reviewed corpus, most studies do not trace the subsequent stage—the direct use of these methods in manufacturing new yarn or fabric from recovered raw materials. Targeted searches using refabrication-specific terminology are therefore required before a definitive research gap can be claimed.

In R9 Recycle, the most concrete role of AI relates to composition recognition and automated sorting. Tsai and Yuan demonstrate the combination of infrared Raman spectroscopy with machine learning and deep learning for the automatic sorting of textile waste [27]. The significance of this approach is determined by the fact that recycling quality depends on the purity and homogeneity of the input stream.

Other studies also link digital technologies to the modernization of recycling systems, reverse logistics, and more precise management of waste flows [8, 11, 29, 25]. Thus, the technological chain can be represented as "sensor-based composition determination → AI classification → sorting → formation of a homogeneous stream → recycling." Unlike many conceptual applications of AI, a sufficiently concrete technological architecture is already emerging for R9.

R10 Recover is represented by only two publications. Digital technologies can support life cycle assessment and process parameter optimization, including scenarios for handling residual streams and energy recovery [30, 31]. However, direct applied research on AI-controlled energy recovery specifically for textile waste remains insufficient.

R11 Re-mine also remains underdeveloped. The potential relevance of this strategy is increasing with the development of smart textiles and e-textiles containing sensors, conductive elements, and other components that may require selective extraction [33, 34, 32]. In such a system, AI can be used to recognize complex compositions and support component routing; however, the existing literature still predominantly describes technological preconditions rather than mature industrial solutions.

Conclusion

The systematic 12R coding shows that AI research in the retrieved fast-fashion and textile corpus is concentrated primarily in R1 Rethink and R2 Reduce. The most frequently identified mechanisms concern demand forecasting, personalization, inventory and production optimization, digital design, and automated quality control. By contrast, several strategies associated with product-life extension and later material loops are represented by substantially fewer coded publications. Because the search query did not explicitly include every 12R-specific term, these low frequencies are interpreted as limited representation in the present corpus rather than definitive evidence of absent research.

The analysis further indicates that operational efficiency and circularity are not equivalent. AI-supported improvements can reduce specific inefficiencies, but an environmental benefit should be claimed only where measurable reductions in waste, resource use, emissions, returns, or material flows are demonstrated. This distinction is central to the answer to RQ3 and prevents technological efficiency from being treated automatically as environmental performance.

Future research should therefore combine broader strategy-specific search strings with empirical assessment of material and environmental outcomes. Particular attention should be paid to repair, refurbishment, remanufacturing, refabrication, recovery, and re-mining, as well as to industrial case studies that quantify the effect of AI on physical resource flows. A further priority is the development of an integrated model linking AI technologies, stages of the textile product life cycle, and the 12R hierarchy so that digitalization of a linear fast-fashion system can be distinguished from digitalization that contributes to measurable circular transformation.

Conflict of Interest

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