

BENCHMARKING REVERSE LOGISTICS PERFORMANCE ACROSS EUROPEAN UNION MEMBER STATES USING CIRCULAR ECONOMY INDICATORS

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Abstract

This study benchmarks material-flow conditions relevant to reverse logistics and circular material recirculation across the 27 Member States of the European Union over the period 2016–2025. Using annual Eurostat data, the analysis combines domestic material consumption, resource productivity, extra-EU imports and exports of recyclable raw materials, trade balance, trade intensity and material import dependency within a descriptive and comparative framework. The results reveal substantial heterogeneity among EU Member States and show that no single indicator can adequately characterise the conditions supporting reverse logistics and circular economy performance. At EU-27 level, domestic material consumption remained broadly stable, while resource productivity increased markedly and recyclable raw-material trade intensified. Romania displayed a distinctive profile, combining high and increasing domestic material consumption, comparatively low resource productivity, rapidly expanding recyclable raw-material exchanges and the lowest material import dependency in the EU in 2025. Romania remained a net exporter of recyclable raw materials throughout the analysed period, although its trade surplus narrowed considerably as imports increased more rapidly than exports. The findings indicate that low import dependency or high participation in secondary-material markets should not be interpreted in isolation as evidence of stronger circularity. The study contributes by integrating complementary macro-level indicators into a common benchmarking framework that supports a more nuanced interpretation of national material-flow patterns relevant to reverse logistics and the circular economy transition.

Keywords: reverse logistics; circular economy; material flows; resource productivity; recyclable raw materials; material import dependency; EU-27

JEL Classification: Q53; Q56; F14

1. Introduction

The transition from a linear economic model towards a circular economy has increased the importance of recovering, reusing and recirculating materials in order to reduce pressure on primary resources and retain economic value within production and consumption systems. Within this transition, reverse logistics plays an important role by supporting the movement of products,

components and materials from points of use back towards recovery, reuse, remanufacturing, recycling or other forms of reintegration into economic activity. Its relevance therefore extends beyond waste management and is increasingly connected with resource efficiency, secondary raw-material markets and the broader organisation of circular material flows.

At the European Union level, the development of circular economy strategies has also increased the need for comparable indicator of describing differences in material use, resource productivity and secondary-material circulation across Member States. However, reverse logistics is commonly examined at firm, supply-chain or sector level, whereas macro-level comparative assessments remain less straightforward. Indicators such as domestic material consumption, resource productivity, recyclable raw-material trade and material import dependency do not directly measure operational reverse logistics efficiency, but they can provide important information about the material-flow conditions within which reverse logistics systems operate.

A comparative assessment becomes particularly relevant because EU Member States differ considerably in their economic structure, material consumption patterns, resource availability, industrial specialisation and participation in secondary-material markets. Similar levels of circular-economy development may therefore conceal very different material-flow configurations. A country may, for example, display low material import dependency while simultaneously recording high domestic material consumption and low resource productivity, whereas another may rely more strongly on imported materials but generate substantially more economic value per unit of material consumed. Likewise, high volumes of recyclable raw-material trade may indicate strong participation in secondary-material markets without necessarily implying greater reverse logistics efficiency.

Against this background, the aim of this study is to benchmark material-flow conditions relevant to reverse logistics across the EU-27 over the 2016–2025 period. The analysis combines domestic material consumption, resource productivity, extra-EU imports and exports of recyclable raw materials, trade balance, trade intensity and material import dependency. Romania is examined within the complete EU-27 framework and compared with the EU-27 aggregate and other Member States in order to identify its relative position and the main characteristics of its material-flow profile.

The contribution of the study lies in integrating indicators that are usually interpreted separately into a common comparative framework linked to reverse logistics and circular material recirculation. In addition to directly reported Eurostat indicators, the analysis derives trade balance and trade intensity from recyclable raw-material import and export data in order to capture both the direction and the overall scale of secondary-material exchanges. Rather than constructing a composite performance score, the study preserves the individual meaning of each indicator and interprets them jointly. This approach allows differences in material pressure, resource efficiency, secondary-material circulation and dependence on imported materials to be examined without assuming that a high or low value for any single indicator necessarily represents superior circular-economy performance.

Based on this analytical perspective, the study addresses the following research questions: **RQ1:** How have domestic material consumption and resource productivity evolved across EU Member States between 2016 and 2025? **RQ2:** How have recyclable raw material flows, their trade balance and trade intensity evolved across EU Member States, and what do these patterns reveal about Member States’ participation in secondary material markets? **RQ3:** How does material import dependency differ across EU Member States, and how does its interpretation change when considered together with material consumption, resource productivity and recyclable raw material flows?

2. Literature review

Reverse logistics supports the recovery and reintegration of products and materials into economic use. Fleischmann et al. (1997) [13] established an early quantitative perspective on reverse flows and product reuse, while Agrawal, Singh and Murtaza (2015) [1] associate reverse logistics with reuse, repair, remanufacturing, recycling and disposal. Govindan, Soleimani and Kannan (2015) [14] extend this perspective through the closed-loop supply chain framework. More recent research strengthens its connection with circular economy: Mishra et al. (2022) [22] emphasise waste management, extended producer responsibility and resource recycling, while Mallick et al. (2023) [20] and Mallick et al. (2024) [21] examine the design and implementation of reverse-logistics systems for end-of-use and end-of-life products. Lozano-Oviedo, Cortés and Rey (2024) [19] and Salas-Navarro et al. (2024) [23] further confirm the increasing integration of reverse logistics, closed-loop supply chains, sustainability and circular economy.

At the macroeconomic level, domestic material consumption and resource productivity provide complementary information on material use and efficiency. Eurostat (2026b) [10] defines DMC as a material-flow indicator derived from domestic extraction, imports and exports, while Eurostat (2026c) [11] defines resource productivity as GDP generated per unit of DMC. Karakaya, Sarı and Alataş (2021) [16] identify substantial heterogeneity in DMC and material-footprint patterns among EU countries, while Islam and Afolabi (2025) [15] identify distinct convergence clubs in EU-27 resource productivity and find a positive relationship between circular material use and membership in higher-productivity groups. D’Adamo et al. (2024) [6], Banjerdpai boon and Limleamthong (2023) [4] and Álvarez et al. (2026) [2] similarly demonstrate that circular-economy performance differs considerably across European countries and benefits from multidimensional assessment.

Secondary raw materials constitute another important dimension of circular material flows. Eurostat (2026d) [12] defines trade in recyclable raw materials as cross-border movements of recyclable waste, scrap and other secondary raw materials and considers the indicator relevant for monitoring secondary-raw-material markets. Kultys (2021) [18] identifies differences in recyclable-material trade across European economies, while Berglund and Söderholm (2003) [5], focusing on waste paper, show the importance of material availability for understanding recycling and trade. The European Commission and WSP (2026) [8] also underline the importance of functioning secondary-raw-material markets for circularity. In the present study, imports and exports are complemented by trade balance, defined as exports minus imports, and trade intensity, defined as imports plus exports, to describe respectively the direction and total scale of extra-EU recyclable-material exchanges.

Material import dependency adds a complementary perspective on reliance on external material inputs. Eurostat (2026a) [9] defines material import dependency as imports relative to direct material input and uses it to describe the extent to which an economy relies on imported materials. Distefano, Lodi and Biggeri (2024) [7] show that material footprint and import dependency in the EU-27 are influenced by technological change, economic structure and consumption patterns. Baldassarre (2025) [3] further argues that circular strategies such as recycling and remanufacturing can contribute to reducing dependence on imported critical raw materials, although appropriate supply-chain configurations are required. These findings indicate that import dependency should be interpreted together with domestic material use, resource productivity and secondary-material circulation.

Recent comparative studies reinforce the need for an integrated perspective. D’Adamo et al. (2024) [6], Banjerdpai boon and Limleamthong (2023) [4], Koca, Egilmez and Ozgulseren (2026) [17] and Álvarez et al. (2026) [2] identify heterogeneous circular-economy performance across EU Member States using different multidimensional methodologies. Building on these research streams, the present study combines domestic material consumption, resource productivity,

recyclable raw-material imports and exports, trade balance, trade intensity and material import dependency over 2016–2025. Rather than treating these indicators as direct measures of operational reverse-logistics efficiency, they are used jointly to benchmark the material-flow conditions relevant to reverse logistics and circular material recirculation across the EU-27.

3. Methodology

This study applies a descriptive and comparative benchmarking approach to assess material-flow conditions relevant to reverse logistics and circular material recirculation across the 27 Member States of the European Union. The analysis covers the period 2016–2025 and uses annual secondary data retrieved from Eurostat. The selected period provides a common ten-year analytical framework and allows both longer-term developments and the most recent available values to be examined. Romania is analysed within the complete EU-27 framework, with the EU-27 aggregate used as the principal benchmark where available.

Four Eurostat datasets were used to construct the analytical framework: Material flow accounts, Resource productivity, Trade in recyclable raw materials and Material import dependency. From these datasets, five directly reported measures were retained: domestic material consumption (tonnes per capita), resource productivity (PPS per kilogram), extra-EU imports of recyclable raw materials (tonnes), extra-EU exports of recyclable raw materials (tonnes), and material import dependency (%). The indicators were selected because they capture complementary dimensions of material use, resource efficiency, secondary-material circulation and reliance on external material inputs.

Two additional indicators were derived from Eurostat data in order to provide a more complete assessment of recyclable raw-material flows. For Member State i in year t , the trade balance was calculated as:

$$\text{Trade Balance}_{it} = \text{Exports}_{it} - \text{Imports}_{it}$$

where positive values indicate a net-exporting position and negative values indicate a net-importing position. Trade intensity was calculated as:

$$\text{Trade Intensity}_{it} = \text{Imports}_{it} + \text{Exports}_{it}$$

and represents the total volume of extra-EU recyclable raw materials exchanged by a Member State. In the present study, the term trade intensity therefore refers specifically to the absolute combined volume of imports and exports and should not be confused with trade-intensity measures normalised by GDP, population or total trade that may be used in other analytical contexts.

The empirical assessment was conducted in three stages corresponding to the analytical structure of the study. First, domestic material consumption and resource productivity were examined jointly to compare the scale of material use with the economic value generated per unit of material consumed. Second, extra-EU imports and exports of recyclable raw materials were analysed together with the derived trade balance and trade intensity to identify the scale and direction of secondary-material exchanges. Third, material import dependency was assessed and interpreted in conjunction with the preceding indicators to provide an integrated benchmarking perspective. For each indicator, annual developments, differences among Member States and Romania's position relative to the EU-27 benchmark were examined. Absolute and percentage changes between 2016 and 2025 were additionally calculated where relevant to support the interpretation of temporal developments.

The methodological approach is intentionally descriptive and comparative rather than causal. The indicators are not aggregated into a composite index and no weighting scheme is applied, thereby preserving their original economic and material interpretation. Consequently, the study

does not treat any individual indicator as a direct measure of reverse logistics efficiency. Instead, the seven measures are interpreted jointly as complementary indicators of the material-flow conditions within which reverse logistics and circular material recirculation operate.

Limitations of the study

Several limitations should be considered when interpreting the results. First, the selected indicators describe macro-level material flows and resource-use characteristics and do not directly measure operational reverse logistics performance at firm or supply-chain level. Consequently, the findings should be interpreted as a benchmarking of material-flow conditions relevant to reverse logistics rather than as a direct assessment of collection efficiency, return rates, recovery yields or reverse-logistics costs. Second, the indicators differ in their units and scale: domestic material consumption is expressed per capita and resource productivity relates economic output to material consumption, whereas recyclable raw-material trade is measured in absolute tonnes. Trade intensity is therefore influenced by factors such as country size, industrial structure, port and logistics functions, and the scale of secondary-material markets, which limits direct interpretation of higher values as better performance.

Third, the trade analysis covers extra-EU flows of recyclable raw materials and therefore does not represent the complete circulation of secondary materials within the EU internal market or within individual Member States. Similarly, a positive trade balance does not necessarily indicate superior circularity, just as low material import dependency does not necessarily imply stronger circular-economy performance, since it may also reflect greater reliance on domestic primary material extraction. Finally, the study relies on Eurostat data as available at the time of extraction. Some observations, particularly for 2025, are flagged by Eurostat as imputed, while a limited number of earlier observations are estimated. These limitations reinforce the need to interpret the seven indicators jointly rather than independently and to avoid causal conclusions based solely on observed cross-country differences.

4. Results analysis and interpretation

The empirical analysis is structured around three complementary dimensions relevant to reverse logistics and circular material flows: material use and resource efficiency, cross-border circulation of recyclable raw materials, and dependence on imported material inputs. The indicators are examined comparatively across the EU-27 over the 2016–2025 period, with particular attention to Romania’s position relative to the EU-27 benchmark and other Member States. Rather than measuring operational reverse logistics performance directly, the analysis benchmarks the material-flow conditions associated with material recovery, secondary-material circulation and resource efficiency.

4.1. Material consumption and resource productivity

This subsection examines the evolution of material use and resource efficiency across EU Member States during 2016–2025. Domestic material consumption provides an indication of the scale of material throughput within national economies, while resource productivity reflects the economic value generated per unit of material consumed. Analysed together, the two indicators provide a complementary perspective on the relationship between material intensity and the efficiency of resource use across the EU.

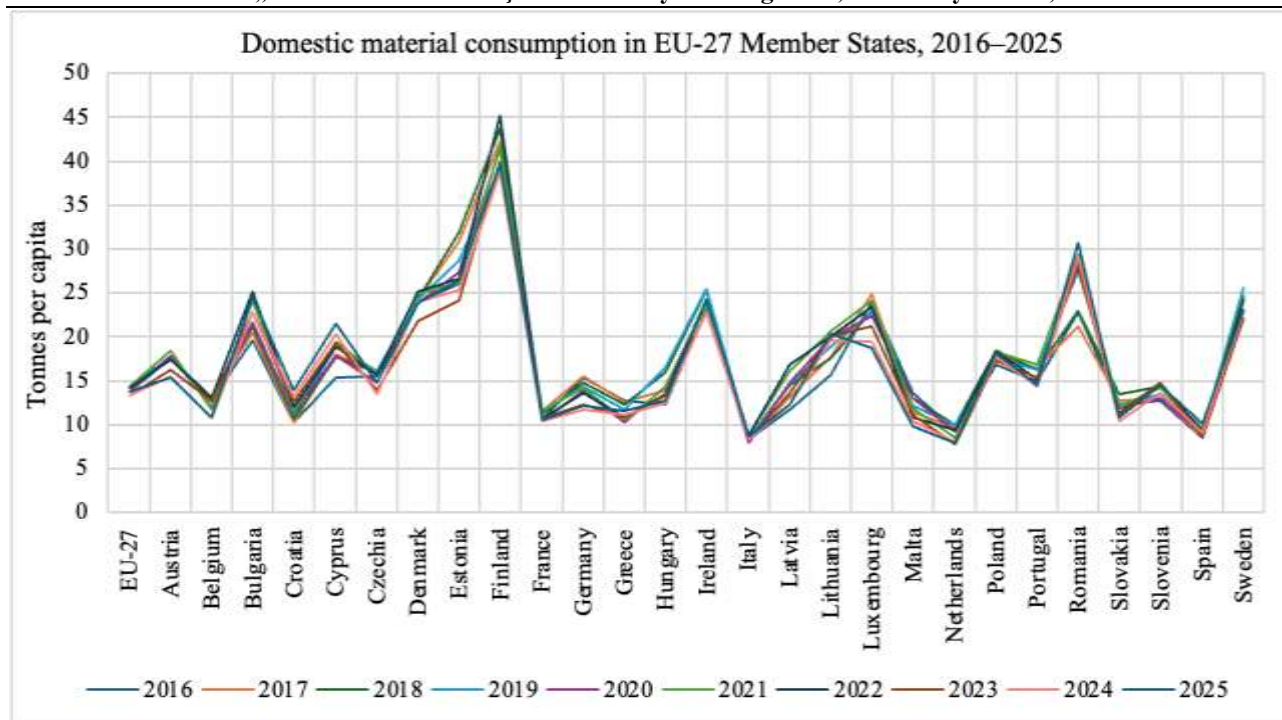


Figure 1. Evolution of domestic material consumption in the EU-27 Member States, 2016–2025
Source: Authors' processing based on Eurostat, Material flow accounts [env_ac_mfa]

Figure 1 shows substantial differences in domestic material consumption across EU Member States during 2016–2025 (Appendix 1). At the EU-27 level, domestic material consumption remained broadly stable, decreasing slightly from 13.788 tonnes per capita in 2016 to 13.746 tonnes per capita in 2025. This relative stability conceals markedly different national trajectories. In 2025, Finland recorded the highest domestic material consumption, at 39.865 tonnes per capita, followed by Romania (30.796 tonnes), Estonia (26.552 tonnes), Bulgaria (24.634 tonnes) and Ireland (24.290 tonnes). By contrast, the Netherlands, Italy and Malta recorded the lowest values, at 7.884, 8.671 and 9.835 tonnes per capita, respectively. These results highlight persistent structural differences in material use across EU economies rather than a uniform convergence pattern.

Romania displayed one of the strongest upward trajectories over the analysed period. Domestic material consumption increased from 22.811 tonnes per capita in 2016 to 30.796 tonnes per capita in 2025, corresponding to an increase of approximately 35.0%, while the EU-27 aggregate remained almost unchanged. By 2025, Romania recorded the second-highest level among EU Member States and a value approximately 2.24 times the EU-27 average. The high level of domestic material consumption indicates greater material throughput and underscores the relevance of effective recovery, return and recirculation systems within reverse logistics. In this context, the indicator should be interpreted as a measure of material pressure rather than as a direct measure of reverse logistics performance.

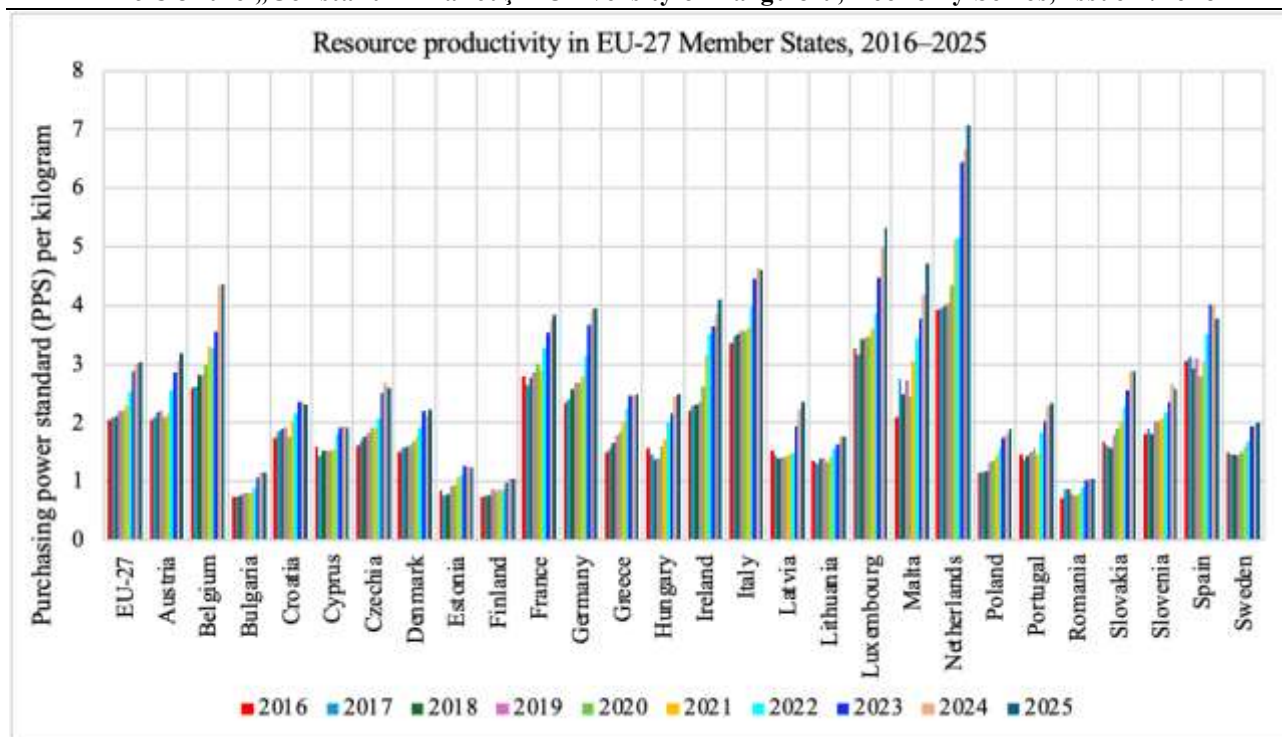


Figure 2. Evolution of resource productivity in the EU-27 Member States, 2016–2025

Source: Authors' processing based on Eurostat, Resource productivity [env_ac_rp]

Figure 2 illustrates substantial differences in resource productivity across EU Member States during 2016–2025 (Appendix 2). At the EU-27 level, resource productivity increased from 2.0631 PPS per kilogram in 2016 to 3.0401 PPS per kilogram in 2025, representing an increase of approximately 47.4%. The overall upward trend indicates that the European economy generated progressively more economic value per unit of material consumed over the analysed period. Nevertheless, considerable disparities persisted among Member States. In 2025, the Netherlands recorded the highest resource productivity, at 7.0658 PPS per kilogram, followed by Luxembourg (5.3378), Malta (4.7173), Italy (4.6073) and Belgium (4.3738). By contrast, Romania and Finland recorded the lowest values, at 1.0505 and 1.0538 PPS per kilogram, respectively, followed by Bulgaria (1.1477) and Estonia (1.2458).

Romania recorded a moderate improvement over the analysed period, with resource productivity increasing from 0.7280 PPS per kilogram in 2016 to 1.0505 PPS per kilogram in 2025, corresponding to an increase of approximately 44.3%. Despite this progress, Romania remained substantially below the EU-27 level. In 2025, Romania's resource productivity represented only around 34.6% of the EU-27 value. This result is particularly relevant when considered together with the high level of domestic material consumption identified in Figure 1. The combination of high material consumption and comparatively low resource productivity suggests that a relatively large material throughput generates comparatively limited economic value per unit of material used. From a reverse logistics perspective, this highlights the importance of improving material recovery, reuse and recirculation mechanisms in order to increase the economic value retained within material flows and support a more resource-efficient circular economy.

4.2. Cross-border flows of recyclable raw materials

This subsection examines the cross-border circulation of recyclable raw materials as an important component of secondary material markets and reverse logistics systems. The analysis considers extra-EU imports and exports and further derives two complementary measures: the trade balance, calculated as exports minus imports, and trade intensity, calculated as the sum of imports

and exports. Together, these indicators allow differences in the scale, direction and overall intensity of recyclable raw material flows across EU Member States to be identified. They therefore provide a broader perspective on the participation of national economies in secondary material markets and on the circulation of recovered materials across borders.

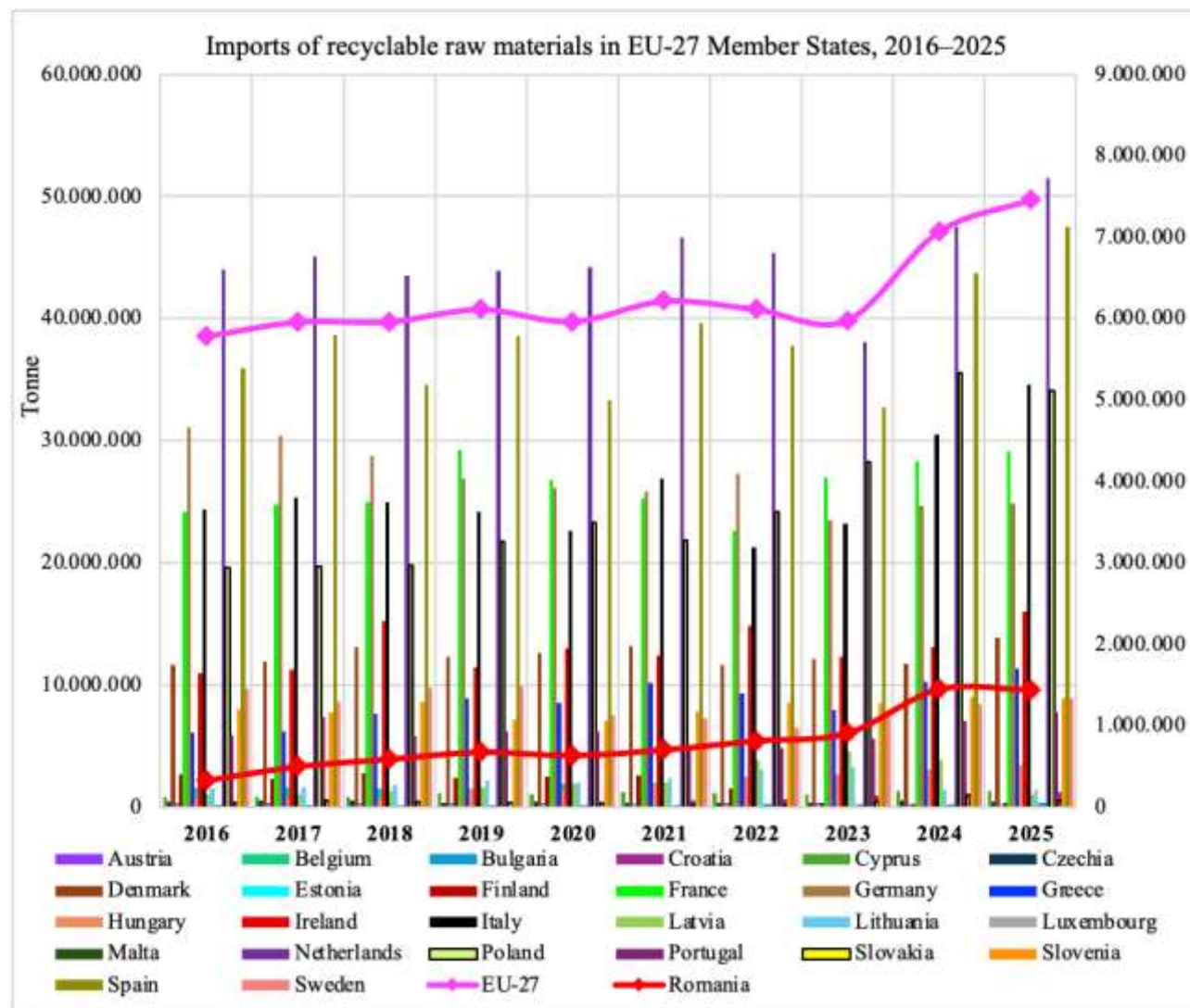


Figure 3. Evolution of imports of recyclable raw materials in the EU-27 Member States, 2016–2025

Source: Authors' processing based on Eurostat, Trade in recyclable raw materials [cei_srm020]

Figure 3 illustrates the evolution of extra-EU imports of recyclable raw materials across EU Member States during 2016–2025 (Appendix 3). At the EU-27 level, imports increased from 38.56 million tonnes in 2016 to 49.73 million tonnes in 2025, indicating a substantial expansion of recyclable raw material inflows over the analysed period. The increase was particularly pronounced after 2023, with EU-27 imports rising from 39.88 million tonnes in 2023 to 47.11 million tonnes in 2024 and 49.73 million tonnes in 2025. Considerable differences were observed among Member States. In 2025, the Netherlands recorded the highest import volume, at 7.72 million tonnes, followed by Spain (7.12 million tonnes), Italy (5.19 million tonnes), Poland (5.11 million tonnes), France (4.37 million tonnes) and Germany (3.72 million tonnes).

Romania exhibited a pronounced upward trajectory, with imports of recyclable raw materials increasing from 329,454 tonnes in 2016 to 1.44 million tonnes in 2025. Particularly strong growth occurred after 2022, with imports reaching 910,125 tonnes in 2023 and approximately 1.45 million

tonnes in 2024. Although the Romanian value decreased slightly to 1.44 million tonnes in 2025, it remained substantially above the level recorded at the beginning of the analysed period. From a reverse logistics perspective, the increasing cross-border movement of recyclable raw materials reflects the growing economic relevance of secondary material flows and the mechanisms required for their collection, recovery, consolidation and reintegration into productive processes. However, import volumes should not be interpreted as a direct measure of reverse logistics performance, as they also reflect differences in economic size, industrial structure and demand for secondary raw materials.

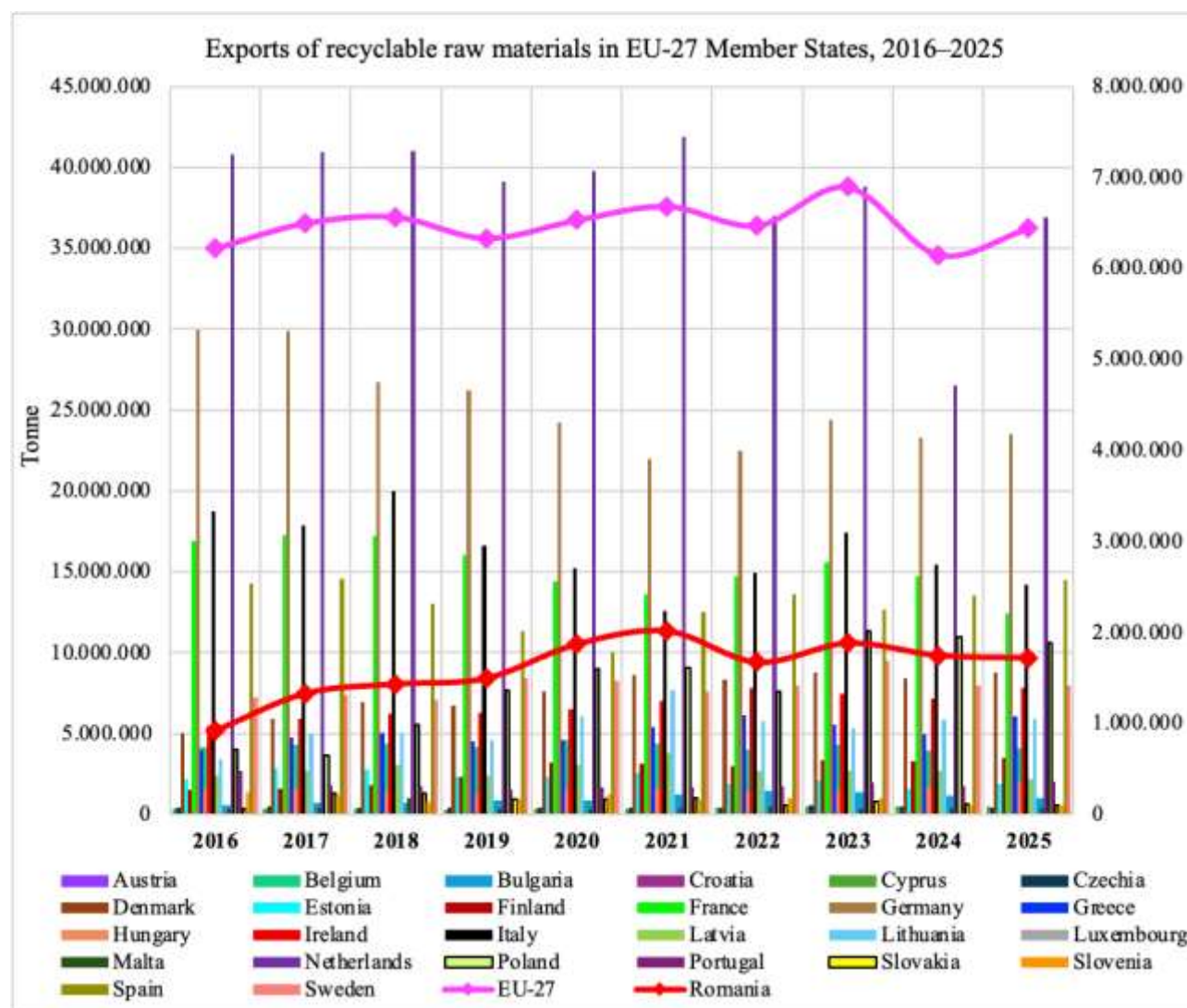


Figure 4. Evolution of exports of recyclable raw materials in the EU-27 Member States, 2016–2025

Source: Authors' processing based on Eurostat, Trade in recyclable raw materials [cei_srm020]

Figure 4 illustrates the evolution of extra-EU exports of recyclable raw materials across EU Member States during 2016–2025 (Appendix 4). At the EU-27 level, exports increased moderately from 34.98 million tonnes in 2016 to 36.23 million tonnes in 2025, although the evolution was characterised by considerable fluctuations. Exports reached 38.80 million tonnes in 2023, declined to 34.60 million tonnes in 2024 and subsequently recovered to 36.23 million tonnes in 2025. Considerable differences were also observed among Member States. In 2025, the Netherlands recorded the highest export volume, at 6.56 million tonnes, followed by Germany (4.17 million

tonnes) and Belgium (4.07 million tonnes), highlighting the concentration of recyclable raw material exports in a limited number of Member States.

Romania recorded a substantial increase in exports over the analysed period, from 919,247 tonnes in 2016 to 1.72 million tonnes in 2025. Exports reached their highest level in 2021, at approximately 2.02 million tonnes, before declining moderately in subsequent years. Nevertheless, the 2025 level remained approximately 87.5% above that recorded in 2016. From a reverse logistics perspective, the expansion of recyclable raw material exports reflects the increasing circulation of recovered materials and their reintegration into secondary material markets. However, as in the case of imports, export volumes should not be interpreted as a direct measure of reverse logistics performance, since they are also influenced by industrial structure, domestic demand and the availability of recyclable materials.

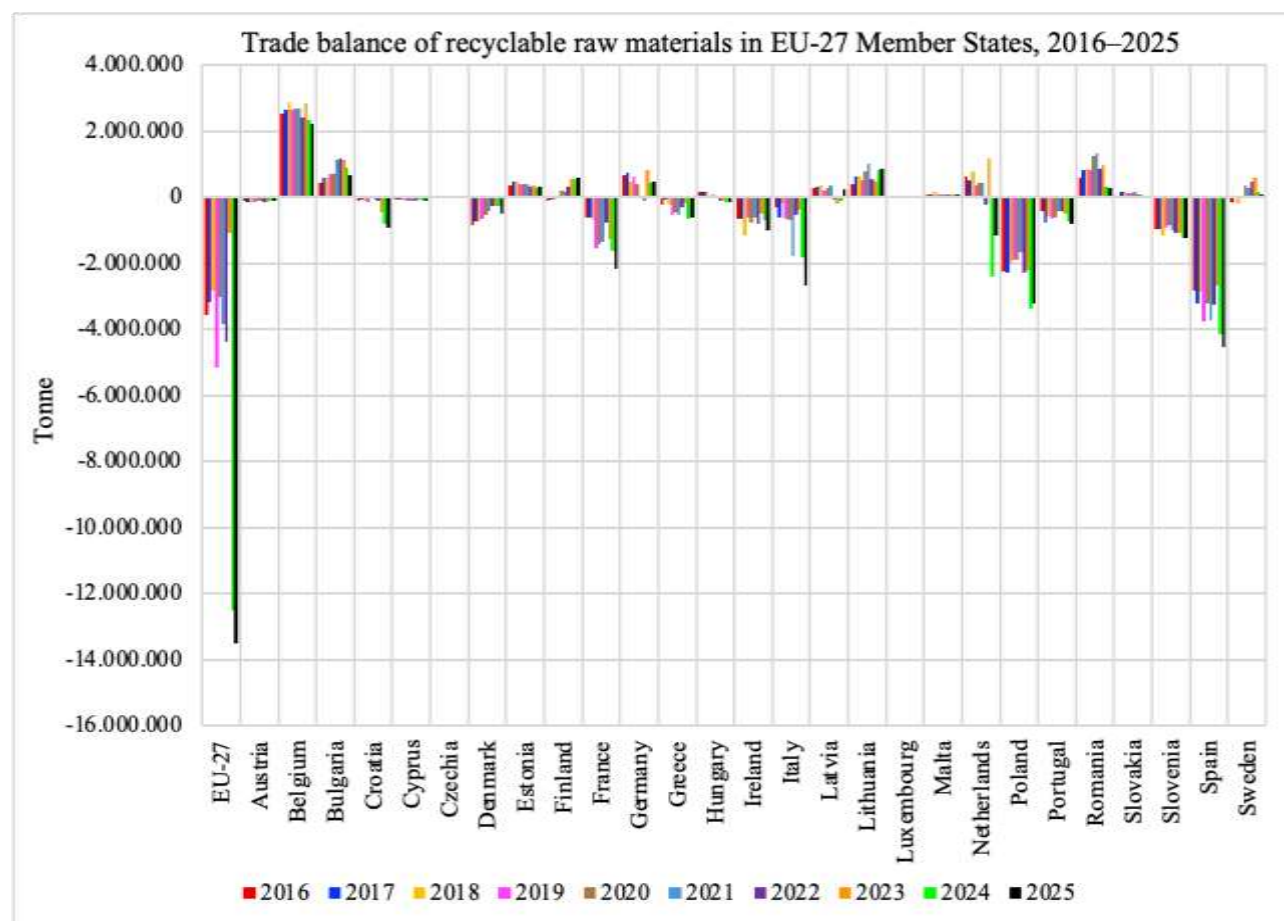


Figure 5. Evolution of the trade balance of recyclable raw materials in the EU-27 Member States, 2016–2025

Source: Authors' calculations based on Eurostat, *Trade in recyclable raw materials* [cei_srm020]

Figure 5 illustrates the evolution of the trade balance of recyclable raw materials across EU Member States during 2016–2025 (Appendix 5). The trade balance was calculated as the difference between exports and imports, with positive values indicating a net-exporting position and negative values indicating a net-importing position. At the EU-27 level, the balance remained negative throughout the analysed period, deteriorating from –3.58 million tonnes in 2016 to –13.50 million tonnes in 2025. The deficit widened particularly strongly in 2024 and 2025, reflecting the substantial increase in recyclable raw material imports observed during the same period. In 2025, Belgium recorded the largest positive trade balance, at approximately 2.22 million tonnes, followed by Lithuania (0.84 million tonnes), Bulgaria (0.66 million tonnes), Finland (0.58 million tonnes)

and Germany (0.45 million tonnes). By contrast, Spain recorded the largest negative balance, at -4.55 million tonnes, followed by Poland (-3.23 million tonnes), Italy (-2.66 million tonnes) and France (-2.15 million tonnes). These differences reveal contrasting national positions within extra-EU secondary material flows, with some Member States acting predominantly as net suppliers and others as net recipients of recyclable raw materials.

Romania maintained a positive trade balance throughout the entire 2016–2025 period, indicating that exports of recyclable raw materials consistently exceeded imports. The surplus increased from 589,793 tonnes in 2016 to a peak of approximately 1.31 million tonnes in 2021, before gradually narrowing to 975,694 tonnes in 2023, 301,883 tonnes in 2024 and 280,184 tonnes in 2025. Overall, the Romanian trade surplus decreased by approximately 52.5% between 2016 and 2025. This decline does not indicate a contraction in recyclable material exchanges, but rather reflects the much faster increase in imports relative to exports in recent years. From a reverse logistics perspective, Romania’s persistent net-exporting position indicates the availability of recovered recyclable materials that enter external secondary material markets. However, the narrowing surplus suggests a gradual rebalancing of these flows, with imported recyclable materials becoming increasingly important. The trade balance should therefore be interpreted as an indicator of a country’s position within secondary material exchanges rather than as a direct measure of reverse logistics efficiency.

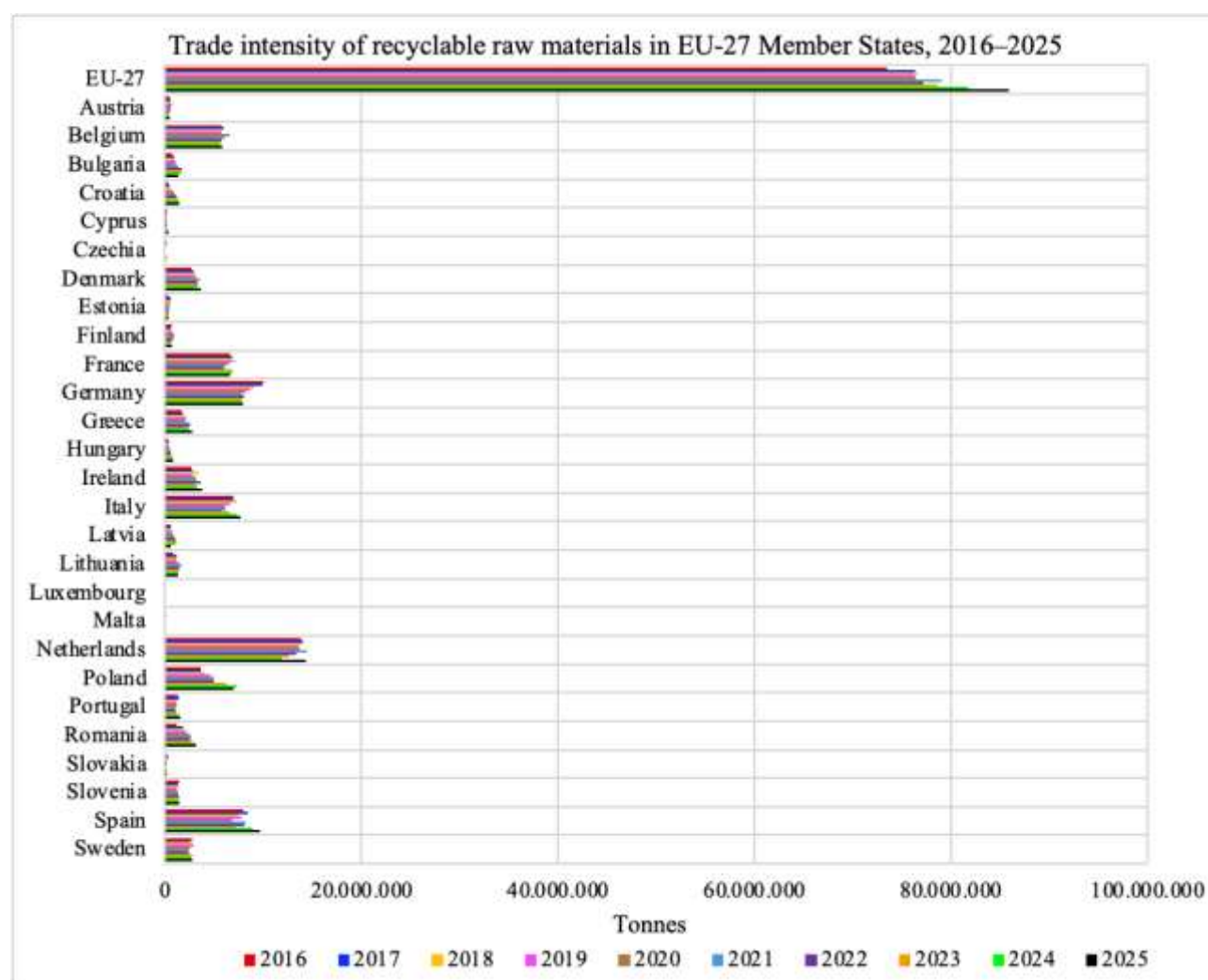


Figure 6. Evolution of trade intensity of recyclable raw materials in the EU-27 Member States, 2016–2025

Source: Authors' calculations based on Eurostat, Trade in recyclable raw materials [cei_srm020]

Figure 6 illustrates the evolution of trade intensity in recyclable raw materials across EU Member States during 2016–2025 (Appendix 6). Trade intensity was calculated as the sum of extra-EU imports and exports, providing an indication of the overall volume of recyclable raw materials exchanged between each Member State and non-EU countries. At the EU-27 level, trade intensity increased from 73.54 million tonnes in 2016 to 85.95 million tonnes in 2025, corresponding to an increase of approximately 16.9%. Although the evolution was relatively stable during most of the analysed period, a more pronounced increase occurred after 2023, when total trade rose from 78.68 million tonnes to 81.72 million tonnes in 2024 and 85.95 million tonnes in 2025. This development was primarily associated with the strong increase in extra-EU imports observed during the final years of the period.

Considerable differences in trade intensity were observed among Member States. In 2025, the Netherlands recorded the highest volume, at approximately 14.28 million tonnes, followed by Spain (9.69 million tonnes), Germany (7.90 million tonnes), Italy (7.73 million tonnes), Poland (6.99 million tonnes) and France (6.59 million tonnes). These results indicate that extra-EU recyclable raw material exchanges are concentrated in a relatively limited group of Member States. However, high trade intensity should not automatically be interpreted as superior circular economy or reverse logistics performance, as the indicator measures the scale of cross-border secondary material flows rather than their efficiency or the proportion of materials successfully recovered and recirculated.

Romania recorded a particularly pronounced increase in trade intensity over the analysed period. The combined volume of imports and exports increased from 1.25 million tonnes in 2016 to 3.17 million tonnes in 2025, representing an increase of approximately 153.6%. Trade intensity reached its highest level in 2024, at approximately 3.20 million tonnes, before declining slightly to 3.17 million tonnes in 2025. This expansion indicates a substantial increase in Romania's participation in extra-EU secondary material exchanges. When considered together with the positive but narrowing trade balance identified in Figure 5, the results show that Romania remained a net exporter of recyclable raw materials while simultaneously experiencing a strong increase in imports. From a reverse logistics perspective, the growing volume of recyclable materials moving across national borders highlights the increasing relevance of collection, recovery, consolidation and recirculation mechanisms supporting secondary material markets. Nevertheless, trade intensity should be interpreted as an indicator of the scale of participation in recyclable material flows rather than as a direct measure of reverse logistics efficiency.

4.3. Material import dependency and integrated benchmarking perspective

This subsection analyses material import dependency and integrates the findings obtained from the previous indicators in order to provide a broader comparative perspective on material-flow patterns across EU Member States. Material import dependency reflects the extent to which national economies rely on imported material inputs, but its interpretation becomes more informative when considered together with domestic material consumption, resource productivity, recyclable raw material imports and exports, as well as the resulting trade balance and trade intensity. This integrated perspective supports a more comprehensive assessment of the material-flow conditions relevant to reverse logistics and circular economy performance.

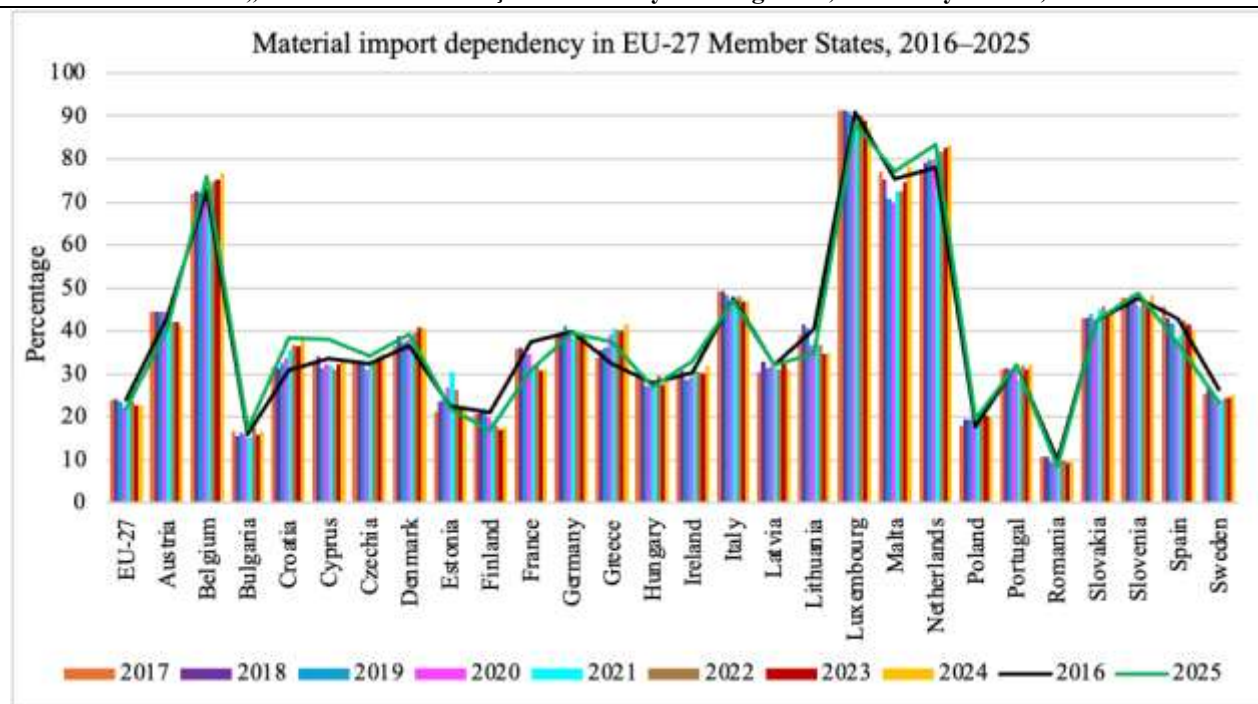


Figure 7. Evolution of material import dependency in the EU-27 Member States, 2016–2025

Source: Authors' processing based on Eurostat, Material import dependency [env_ac_mid]

Figure 7 highlights substantial differences in material import dependency across EU Member States during 2016–2025 (Appendix 7). At the EU-27 level, material import dependency decreased slightly from 24.1% in 2016 to 22.1% in 2025, indicating a relatively stable overall dependence on imported material inputs. However, considerable disparities persisted among Member States. In 2025, Luxembourg recorded the highest level of material import dependency, at 88.3%, followed by the Netherlands (83.4%), Malta (77.1%) and Belgium (76.0%). By contrast, Romania recorded the lowest value among EU Member States, at 8.6%, followed by Finland (16.9%), Bulgaria (17.2%) and Poland (19.7%).

Romania's material import dependency decreased from 10.0% in 2016 to 8.6% in 2025, remaining substantially below the EU-27 level throughout the analysed period. This low dependency indicates that the Romanian economy relies comparatively less on imported material inputs and more strongly on domestically available resources. Nevertheless, when interpreted together with the high domestic material consumption identified in Figure 1 and the comparatively low resource productivity shown in Figure 2, the result should not automatically be considered evidence of stronger circular economy performance. Rather, it may reflect a material-intensive economic structure supported by substantial domestic resource extraction. From a reverse logistics perspective, these findings reinforce the importance of increasing the recovery and recirculation of secondary materials in order to reduce reliance on primary material extraction while improving resource efficiency.

5. Conclusions

This study benchmarked material-flow conditions relevant to reverse logistics and circular material recirculation across the EU-27 during 2016–2025 using seven complementary indicators. The analysis combined domestic material consumption, resource productivity, extra-EU imports and exports of recyclable raw materials, trade balance, trade intensity and material import dependency. The results confirm substantial and persistent differences among EU Member States, indicating that the transition towards more circular material systems follows heterogeneous national trajectories rather than a uniform European pattern.

In relation to **RQ1**, the results show that domestic material consumption and resource productivity evolved differently across the EU. At the EU-27 level, domestic material consumption remained broadly stable, while resource productivity increased substantially during the analysed period. However, these aggregate developments conceal pronounced differences among Member States. Romania represents a particularly relevant case: domestic material consumption increased by approximately 35.0%, reaching 30.796 tonnes per capita in 2025 and the second-highest value in the EU, while resource productivity remained the lowest among Member States at 1.0505 PPS per kilogram. Although Romania improved its resource productivity by approximately 44.3% between 2016 and 2025, its 2025 value represented only around 34.6% of the EU-27 level. The combined interpretation of the two indicators therefore points to a material-intensive economic pattern in which high material throughput is accompanied by comparatively limited economic value generated per unit of material consumed.

Regarding **RQ2**, the analysis reveals an expansion of recyclable raw-material exchanges and substantial differences in Member States' participation in extra-EU secondary-material markets. EU-27 imports increased more strongly than exports, resulting in a widening negative recyclable raw-material trade balance, from approximately -3.58 million tonnes in 2016 to -13.50 million tonnes in 2025. At the same time, total trade intensity increased from 73.54 million tonnes to 85.95 million tonnes. Romania followed a distinct trajectory. Its imports increased from approximately 0.33 million tonnes to 1.44 million tonnes, while exports increased from 0.92 million tonnes to 1.72 million tonnes. Romania remained a net exporter throughout the entire period, although its trade surplus narrowed considerably to approximately 0.28 million tonnes in 2025. At the same time, its trade intensity increased by approximately 153.6%, indicating substantially greater participation in extra-EU recyclable-material exchanges. These developments suggest stronger integration into secondary-material markets, but they should not be interpreted as direct evidence of greater reverse logistics efficiency.

With respect to **RQ3**, material import dependency also reveals significant structural differences across the EU. Romania recorded the lowest material import dependency among Member States in 2025, at 8.6%, compared with an EU-27 level of 22.1%. Considered in isolation, this could suggest relatively low exposure to external material inputs. However, when assessed together with Romania's high domestic material consumption and low resource productivity, the result indicates that low import dependency may also reflect a stronger reliance on domestically available primary resources. The indicator therefore reinforces the importance of integrated interpretation: reduced material import dependency does not necessarily correspond to stronger circularity unless it is accompanied by more efficient material use and greater retention of value through recovery and recirculation.

Taken together, the findings indicate that Romania combines four distinctive characteristics: high and increasing material consumption, comparatively low resource productivity, rapidly expanding recyclable raw-material trade and very low material import dependency. This configuration suggests that Romania possesses a substantial domestic material base and is increasingly active in secondary-material exchanges, but that these characteristics have not yet translated into resource efficiency comparable with the EU-27 benchmark. From a reverse logistics perspective, the main challenge is therefore not simply to increase the quantity of materials entering recovery and trade channels, but to strengthen the capacity to retain their economic value through collection, reuse, recycling, remanufacturing and reintegration into domestic productive processes.

From a broader EU perspective, the study demonstrates that no single material-flow indicator can adequately characterise the conditions supporting reverse logistics and circular economy performance. High recyclable-material trade intensity, a positive trade balance or low import dependency can coexist with high material consumption or low resource productivity. Consequently, multidimensional benchmarking provides a more meaningful basis for understanding Member States' material-flow profiles than isolated indicator rankings.

The study contributes to the literature by linking macro-level circular-economy indicators with the broader functioning of reverse logistics systems without treating them as direct operational performance measures. The proposed framework can support comparative monitoring of national material-flow patterns and can help identify where greater emphasis may be required on resource efficiency, domestic recovery capacity and secondary-material reintegration. Future research could extend the analysis by incorporating intra-EU recyclable-material flows, sector-level indicators, recycling and recovery performance, or firm-level reverse logistics measures in order to connect macroeconomic material-flow patterns more directly with operational reverse logistics performance.

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Appendix

Appendix 1. Domestic material consumption in the EU-27 Member States, 2016–2025

Dataset: Material flow accounts [env_ac_mfa]										
Time frequency: Annual										
Environment indicator: Domestic material consumption										
Materials: Total										
Unit of measure: Tonnes per capita										
TIME	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
EU-27	13,788	14,155	14,366	14,355	13,779	14,43	14,285	13,385	13,308	13,746
Austria	17,654	17,574	17,544	17,767	17,861	18,519	17,489	16,21	15,595	15,367
Belgium	12,909	13,162	12,619	13,083	11,979	11,699	13,015	12,713	10,738	10,92
Bulgaria	19,564	20,46	21,278	21,746	21,617	24,124	25,183	22,862	22,92	24,634

Dataset: Material flow accounts [env_ac_mfa]										
Time frequency: Annual										
Environment indicator: Domestic material consumption										
Materials: Total										
Unit of measure: Tonnes per capita										
TIME	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Croatia	10,255	10,273	10,68	11,136	11,425	11,611	11,981	12,631	13,176	13,947
Cyprus	15,354	18,049	17,768	18,884	17,893	19,478	18,933	19,401	20,311	21,569
Czechia	15,609	15,8	16,002	16,085	14,859	15,868	15,752	13,921	13,47	14,781
Denmark	24,007	24,251	24,259	24,36	23,918	24,881	25,23	21,851	23,965	23,92
Estonia	26,053	30,942	31,93	28,735	27,404	26,275	26,712	24,154	25,284	26,552
Finland	41,716	42,302	43,757	39,323	41,425	41,62	45,199	39,903	38,836	39,865
France	10,674	11,562	11,304	11,589	10,472	11,556	10,708	10,733	10,449	10,597
Germany	15,346	15,469	14,852	14,327	13,909	14,271	13,713	12,312	11,781	12,142
Greece	12,751	12,606	12,305	11,698	10,301	10,573	10,815	10,792	11,213	11,624
Hungary	12,357	13,895	15,926	16,556	14,347	14,29	13,489	13,36	12,488	12,757
Ireland	22,959	24,078	25,374	25,489	23,759	23,523	24,246	22,865	22,852	24,29
Italy	8,348	8,347	8,402	8,463	7,97	8,786	8,884	8,45	8,431	8,671
Latvia	11,739	13,261	14,536	14,667	14,823	16,117	16,863	13,662	12,31	12,374
Lithuania	15,652	17,737	17,587	18,841	19,932	20,689	20,105	20,071	19,674	20,395
Luxembourg	24,074	24,896	23,035	22,872	22,461	24,163	23,485	21,31	19,547	18,802
Malta	13,594	11,401	13,072	12,219	13,074	11,842	10,849	11,119	10,456	9,835
Netherlands	9,398	9,76	9,971	10,049	9,198	8,57	9,406	7,782	8,037	7,884
Poland	16,917	18,005	18,472	17,586	17,58	18,251	18,308	17,354	17,789	18,161
Portugal	14,972	16,403	16,266	16,329	14,462	16,883	15,209	15,325	14,362	14,589
Romania	22,811	21,215	22,993	27,525	28,479	29,386	29,161	27,966	29,099	30,796
Slovakia	12,396	12,786	13,502	12,281	11,871	12,037	11,31	11,213	10,44	10,909
Slovenia	12,81	13,073	14,365	13,561	13,114	14,168	14,783	14,822	13,604	14,588
Spain	8,563	8,741	9,479	9,221	8,952	9,208	9,046	8,637	9,057	10,146
Sweden	23,167	24,1	24,654	25,618	24,315	24,749	24,348	22,103	22,813	23,196

Appendix 2. Resource productivity in the EU-27 Member States, 2016–2025

Dataset: Resource productivity [env_ac_rp]										
Time frequency: Annual										
Unit of measure: Purchasing power standard (PPS) per kilogram										
TIME	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
EU-27	2,0631	2,0911	2,1287	2,2035	2,2074	2,2991	2,5328	2,875	3,0122	3,0401
Austria	2,0617	2,1055	2,1891	2,2093	2,0932	2,1689	2,5516	2,8617	3,0477	3,193
Belgium	2,6053	2,6226	2,8195	2,8193	2,9928	3,308	3,267	3,5685	4,3384	4,3738
Bulgaria	0,7366	0,7492	0,7648	0,8005	0,8083	0,8186	0,8903	1,0609	1,1485	1,1477
Croatia	1,7487	1,8623	1,8903	1,9302	1,767	2,0296	2,1699	2,3638	2,3576	2,326
Cyprus	1,5946	1,4373	1,5367	1,529	1,5198	1,5599	1,8219	1,9277	1,9426	1,9126
Czechia	1,622	1,7105	1,7645	1,8443	1,9277	1,9213	2,075	2,5155	2,6833	2,5991
Denmark	1,4994	1,5655	1,5999	1,6178	1,6742	1,7774	1,9221	2,2133	2,1184	2,2202
Estonia	0,8518	0,766	0,7884	0,9187	0,9481	1,0742	1,11	1,2632	1,2502	1,2458
Finland	0,742	0,767	0,7633	0,8646	0,8219	0,8704	0,8486	0,9935	1,052	1,0538
France	2,7904	2,6418	2,7824	2,8695	3,0184	2,896	3,2829	3,5456	3,7606	3,8488
Germany	2,3336	2,4042	2,5716	2,6925	2,6962	2,7995	3,1364	3,6661	3,9375	3,9483
Greece	1,506	1,5726	1,6544	1,7915	1,8513	2,0347	2,253	2,4709	2,4782	2,4882
Hungary	1,584	1,4696	1,3736	1,3996	1,5844	1,7358	2,0161	2,1683	2,4379	2,4798
Ireland	2,2069	2,2939	2,3082	2,3486	2,6263	3,1647	3,5254	3,6454	3,8638	4,0966
Italy	3,3685	3,4679	3,5178	3,5858	3,5615	3,6173	3,9788	4,4614	4,6339	4,6073

Dataset: Resource productivity [env_ac_rp]										
Time frequency: Annual										
Unit of measure: Purchasing power standard (PPS) per kilogram										
TIME	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Latvia	1,5269	1,432	1,391	1,4278	1,411	1,4609	1,4807	1,9528	2,2314	2,3567
Lithuania	1,3657	1,3008	1,4071	1,4002	1,3225	1,4151	1,5553	1,6407	1,7757	1,7725
Luxembourg	3,2711	3,1725	3,4337	3,4513	3,4717	3,6106	3,8619	4,4729	5,0082	5,3378
Malta	2,0951	2,7572	2,4994	2,7354	2,4416	3,0607	3,4495	3,7705	4,2038	4,7173
Netherlands	3,9293	3,9439	4,0004	4,0352	4,3475	5,1042	5,1607	6,4528	6,6504	7,0658
Poland	1,1645	1,151	1,1874	1,327	1,3477	1,435	1,5773	1,7447	1,8154	1,9075
Portugal	1,4612	1,3754	1,4477	1,4982	1,5771	1,4541	1,8306	2,0346	2,2933	2,3303
Romania	0,728	0,8723	0,8666	0,7898	0,767	0,8147	0,8886	1,027	1,0576	1,0505
Slovakia	1,6737	1,6249	1,5826	1,7998	1,9012	2,0312	2,2668	2,5549	2,8746	2,8738
Slovenia	1,8207	1,901	1,8232	2,0323	2,0346	2,0676	2,1849	2,3663	2,6543	2,5849
Spain	3,0514	3,1294	2,9342	3,1065	2,8064	3,0655	3,5132	4,0254	4,0191	3,7728
Sweden	1,5045	1,4646	1,4568	1,4448	1,5079	1,6029	1,6865	1,9347	1,9739	2,017

Appendix 3. Imports of recyclable raw materials in the EU-27 Member States, 2016–2025

Dataset: Trade in recyclable raw materials [cei_srm020]										
Time frequency: Annual										
Raw materials: Total										
Stock or flow: Imports extra-EU27 (from 2020)										
Unit of measure: Tonne										
TIME	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
EU-27	38.559.468	39.747.212	39.770.674	40.775.429	39.778.635	41.449.837	40.787.446	39.879.216	47.114.343	49.725.370
Austria	320.436	362.544	374.526	393.526	362.788	350.357	325.513	323.993	279.611	284.558
Belgium	1.631.874	1.662.807	1.504.426	1.523.393	1.948.981	1.748.087	1.636.000	1.465.214	1.637.296	1.851.150
Bulgaria	146.354	184.052	160.701	166.439	175.058	118.570	273.591	302.390	307.844	328.404
Croatia	212.146	255.851	298.764	448.870	456.310	573.660	650.675	910.284	1.137.970	1.204.730
Cyprus	120.594	129.559	129.647	166.553	159.645	179.155	174.527	152.817	206.110	200.317
Czechia	63.610	78.243	83.630	48.798	66.845	51.175	55.807	51.923	76.866	68.515
Denmark	1.747.918	1.792.950	1.965.787	1.853.931	1.897.572	1.977.881	1.750.732	1.817.162	1.764.131	2.074.599
Estonia	27.765	30.505	32.953	35.839	36.853	50.404	26.544	23.658	28.155	41.611
Finland	397.175	351.593	411.819	366.132	379.628	387.918	224.128	55.395	36.988	53.642
France	3.630.894	3.709.571	3.747.237	4.387.590	4.019.138	3.785.198	3.394.356	4.048.134	4.256.189	4.370.968
Germany	4.668.685	4.562.114	4.307.106	4.035.430	3.926.042	3.870.615	4.099.080	3.529.796	3.703.988	3.723.217
Greece	919.679	923.662	1.142.067	1.336.625	1.281.745	1.521.200	1.400.662	1.190.987	1.541.550	1.707.328
Hungary	101.503	123.428	91.720	207.577	195.707	303.041	379.716	397.448	466.871	516.034
Ireland	1.641.486	1.693.581	2.280.016	1.718.116	1.948.448	1.868.935	2.220.474	1.843.127	1.965.962	2.403.677
Italy	3.651.818	3.801.535	3.748.682	3.627.904	3.399.183	4.032.403	3.184.733	3.474.989	4.568.257	5.193.768
Latvia	153.177	148.615	193.775	246.318	280.664	304.955	572.195	679.362	577.803	162.080
Lithuania	233.591	248.736	275.006	329.265	302.842	354.222	469.386	495.055	213.723	214.137
Luxembourg	16.859	16.279	30.150	17.139	12.055	24.870	14.674	32.526	39.669	20.535
Malta	2.411	2.464	4.053	2.081	3.509	1.118	2.478	3.167	3.500	2.928
Netherlands	6.608.883	6.763.540	6.523.721	6.587.560	6.628.357	7.001.424	6.810.703	5.714.508	7.131.527	7.719.478
Poland	2.948.184	2.958.836	2.973.318	3.267.749	3.499.503	3.282.768	3.631.087	4.241.737	5.339.843	5.112.304
Portugal	890.244	1.109.818	876.319	926.841	931.813	717.022	723.346	847.375	1.065.302	1.158.460
Romania	329.454	502.225	592.489	679.404	638.189	706.778	817.602	910.125	1.448.807	1.443.546
Slovakia	50.108	83.299	72.347	55.071	36.606	31.290	24.482	70.480	145.334	82.188
Slovenia	1.202.497	1.163.879	1.295.358	1.076.329	1.057.831	1.180.946	1.276.110	1.275.506	1.354.868	1.331.881
Spain	5.386.326	5.798.219	5.183.097	5.790.173	5.005.185	5.940.087	5.676.294	4.912.742	6.557.706	7.122.325
Sweden	1.455.795	1.289.306	1.471.960	1.480.775	1.128.138	1.085.756	972.553	1.109.316	1.258.473	1.332.989

Appendix 4. Exports of recyclable raw materials in the EU-27 Member States, 2016–2025

Dataset: Trade in recyclable raw materials [cei_srm020]										
Time frequency: Annual										
Raw materials: Total										
Stock or flow: Exports extra-EU27 (from 2020)										
Unit of measure: Tonne										
TIME	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
EU-27	34.979.700	36.555.474	36.942.557	35.625.431	36.738.496	37.607.533	36.415.734	38.800.528	34.602.325	36.228.140
Austria	192.567	204.203	207.732	258.314	242.099	246.142	183.036	182.871	186.065	172.813
Belgium	4.166.067	4.293.247	4.377.464	4.177.818	4.646.727	4.412.365	4.062.002	4.303.710	3.983.524	4.066.989
Bulgaria	571.090	754.780	736.440	879.691	861.593	1.257.044	1.435.365	1.420.959	1.198.829	990.744
Croatia	110.350	163.086	192.438	278.430	483.165	487.590	548.672	455.270	328.804	291.669
Cyprus	64.716	61.446	61.905	57.130	62.770	69.398	80.963	90.008	86.238	87.553
Czechia	83.089	86.967	79.689	73.929	77.082	83.585	72.845	101.065	84.791	79.225
Denmark	899.032	1.059.277	1.232.104	1.192.375	1.347.603	1.537.810	1.490.704	1.559.044	1.502.283	1.556.272
Estonia	385.588	513.663	494.159	411.241	413.536	455.265	343.383	380.225	285.216	342.061
Finland	275.401	286.815	325.366	417.153	570.316	562.529	529.589	601.110	588.203	631.194
France	3.007.002	3.074.564	3.064.967	2.854.539	2.570.891	2.416.464	2.617.839	2.767.192	2.620.917	2.218.301
Germany	5.330.733	5.307.032	4.758.684	4.655.236	4.305.494	3.910.476	4.001.602	4.339.624	4.137.709	4.173.585
Greece	704.379	850.391	895.533	803.811	818.233	966.510	1.092.832	986.961	883.823	1.078.687
Hungary	268.763	289.390	257.639	237.219	282.177	291.818	259.927	269.637	301.740	366.272
Ireland	981.647	1.049.490	1.107.845	1.116.831	1.160.518	1.254.792	1.392.248	1.327.171	1.278.680	1.386.992
Italy	3.327.628	3.181.247	3.555.715	2.952.838	2.710.581	2.239.797	2.652.748	3.100.637	2.746.447	2.531.264
Latvia	424.821	475.303	540.907	432.861	542.271	675.179	480.753	478.460	481.303	392.994
Lithuania	610.488	885.858	891.795	824.488	1.078.415	1.363.793	1.029.322	948.156	1.043.570	1.054.738
Luxembourg	524	1.160	776	1.473	438	258	166	200	197	1.024
Malta	69.965	75.092	176.922	66.817	66.930	76.024	86.359	66.227	83.396	79.895
Netherlands	7.248.642	7.283.019	7.286.911	6.952.526	7.071.759	7.445.639	6.574.837	6.898.990	4.717.969	6.563.176
Poland	712.212	653.288	994.321	1.369.565	1.597.024	1.614.874	1.359.980	2.016.587	1.958.737	1.882.607
Portugal	482.138	322.232	306.724	269.551	305.375	298.621	318.412	356.249	314.034	363.715
Romania	919.247	1.333.063	1.436.823	1.499.956	1.872.834	2.018.004	1.676.579	1.885.819	1.750.690	1.723.730
Slovakia	59.970	237.926	229.775	168.895	172.213	185.201	100.332	146.572	121.029	104.462
Slovenia	251.374	211.668	145.269	165.310	222.040	159.810	176.510	177.578	99.010	98.099
Spain	2.540.265	2.588.851	2.320.516	2.014.815	1.788.048	2.221.269	2.423.879	2.247.833	2.402.892	2.571.633
Sweden	1.291.999	1.312.419	1.264.140	1.492.617	1.468.364	1.357.275	1.424.850	1.692.375	1.416.228	1.418.447

Appendix 5. Trade balance of recyclable raw materials in the EU-27 Member States, 2016–2025

Indicator: Trade balance of recyclable raw materials										
Calculation: Exports – Imports										
Unit of measure: Tonne										
Period: 2016–2025										
TIME	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
EU-27	-3.579.768	-3.191.738	-2.828.117	-5.149.998	-3.040.139	-3.842.304	-4.371.712	-1.078.688	-12.512.018	-13.497.230
Austria	-127.869	-158.341	-166.794	-135.212	-120.689	-104.215	-142.477	-141.122	-93.546	-111.745
Belgium	2.534.193	2.630.440	2.873.038	2.654.425	2.697.746	2.664.278	2.426.002	2.838.496	2.346.228	2.215.839
Bulgaria	424.736	570.728	575.739	713.252	686.535	1.138.474	1.161.774	1.118.569	890.985	662.340
Croatia	-101.796	-92.765	-106.326	-170.440	26.855	-86.070	-102.003	-455.014	-809.166	-913.061
Cyprus	-55.878	-68.113	-67.742	-109.423	-96.875	-109.757	-93.564	-62.809	-119.872	-112.764
Czechia	19.479	8.724	-3.941	25.131	10.237	32.410	17.038	49.142	7.925	10.710
Denmark	-848.886	-733.673	-733.683	-661.556	-549.969	-440.071	-260.028	-258.118	-261.848	-518.327
Estonia	357.823	483.158	461.206	375.402	376.683	404.861	316.839	356.567	257.061	300.450
Finland	-121.774	-64.778	-86.453	51.021	190.688	174.611	305.461	545.715	551.215	577.552
France	-623.892	-635.007	-682.270	-1.533.051	-1.448.247	-1.368.734	-776.517	-1.280.942	-1.635.272	-2.152.667
Germany	662.048	744.918	451.578	619.806	379.452	39.861	-97.478	809.828	433.721	450.368
Greece	-215.300	-73.271	-246.534	-532.814	-463.512	-554.690	-307.830	-204.026	-657.727	-628.641
Hungary	167.260	165.962	165.919	29.642	86.470	-11.223	-119.789	-127.811	-165.131	-149.762
Ireland	-659.839	-644.091	-1.172.171	-601.285	-787.930	-614.143	-828.226	-515.956	-687.282	-1.016.685
Italy	-324.190	-620.288	-192.967	-675.066	-688.602	-1.792.606	-531.985	-374.352	-1.821.810	-2.662.504
Latvia	271.644	326.688	347.132	186.543	261.607	370.224	-91.442	-200.902	-96.500	230.914
Lithuania	376.897	637.122	616.789	495.223	775.573	1.009.571	559.936	453.101	829.847	840.601
Luxembourg	-16.335	-15.119	-29.374	-15.666	-11.617	-24.612	-14.508	-32.326	-39.472	-19.511
Malta	67.554	72.628	172.869	64.736	63.421	74.906	83.881	63.060	79.896	76.967

Indicator: Trade balance of recyclable raw materials										
Calculation: Exports – Imports										
Unit of measure: Tonne										
Period: 2016–2025										
TIME	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Netherlands	639.759	519.479	763.190	364.966	443.402	444.215	-235.866	1.184.482	-2.413.558	-1.156.302
Poland	-2.235.972	-2.305.548	-1.978.997	-1.898.184	-1.902.479	-1.667.894	-2.271.107	-2.225.150	-3.381.106	-3.229.697
Portugal	-408.106	-787.586	-569.595	-657.290	-626.438	-418.401	-404.934	-491.126	-751.268	-794.745
Romania	589.793	830.838	844.334	820.552	1.234.645	1.311.226	858.977	975.694	301.883	280.184
Slovakia	9.862	154.627	157.428	113.824	135.607	153.911	75.850	76.092	-24.305	22.274
Slovenia	-951.123	-952.211	-1.150.089	-911.019	-835.791	-1.021.136	-1.099.600	-1.097.928	-1.255.858	-1.233.782
Spain	-2.846.061	-3.209.368	-2.862.581	-3.775.358	-3.217.137	-3.718.818	-3.252.415	-2.664.909	-4.154.814	-4.550.692
Sweden	-163.796	23.113	-207.820	11.842	340.226	271.519	452.297	583.059	157.755	85.458

Appendix 6. Trade intensity of recyclable raw materials in the EU-27 Member States, 2016–2025

Indicator: Trade intensity of recyclable raw materials										
Calculation: Imports + Exports										
Unit of measure: Tonne										
Period: 2016–2025										
TIME	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
EU-27	73.539.168	76.302.686	76.713.231	76.400.860	76.517.131	79.057.370	77.203.180	78.679.744	81.716.668	85.953.510
Austria	513.003	566.747	582.258	651.840	604.887	596.499	508.549	506.864	465.676	457.371
Belgium	5.797.941	5.956.054	5.881.890	5.701.211	6.595.708	6.160.452	5.698.002	5.768.924	5.620.820	5.918.139
Bulgaria	717.444	938.832	897.141	1.046.130	1.036.651	1.375.614	1.708.956	1.723.349	1.506.673	1.319.148
Croatia	322.496	418.937	491.202	727.300	939.475	1.061.250	1.199.347	1.365.554	1.466.774	1.496.399
Cyprus	185.310	191.005	191.552	223.683	222.415	248.553	255.490	242.825	292.348	287.870
Czechia	146.699	165.210	163.319	122.727	143.927	134.760	128.652	152.988	161.657	147.740
Denmark	2.646.950	2.852.227	3.197.891	3.046.306	3.245.175	3.515.691	3.241.436	3.376.206	3.266.414	3.630.871
Estonia	413.353	544.168	527.112	447.080	450.389	505.669	369.927	403.883	313.371	383.672
Finland	672.576	638.408	737.185	783.285	949.944	950.447	753.717	656.505	625.191	684.836
France	6.637.896	6.784.135	6.812.204	7.242.129	6.590.029	6.201.662	6.012.195	6.815.326	6.877.106	6.589.269
Germany	9.999.418	9.869.146	9.065.790	8.690.666	8.231.536	7.781.091	8.100.682	7.869.420	7.841.697	7.896.802
Greece	1.624.058	1.774.053	2.037.600	2.140.436	2.099.978	2.487.710	2.493.494	2.177.948	2.425.373	2.786.015
Hungary	370.266	412.818	349.359	444.796	477.884	594.859	639.643	667.085	768.611	882.306
Ireland	2.623.133	2.743.071	3.387.861	2.834.947	3.108.966	3.123.727	3.612.722	3.170.298	3.244.642	3.790.669
Italy	6.979.446	6.982.782	7.304.397	6.580.742	6.109.764	6.272.200	5.837.481	6.575.626	7.314.704	7.725.032
Latvia	577.998	623.918	734.682	679.179	822.935	980.134	1.052.948	1.157.822	1.059.106	555.074
Lithuania	844.079	1.134.594	1.166.801	1.153.753	1.381.257	1.718.015	1.498.708	1.443.211	1.257.293	1.268.875
Luxembourg	17.383	17.439	30.926	18.612	12.493	25.128	14.840	32.726	39.866	21.559
Malta	72.376	77.556	180.975	68.898	70.439	77.142	88.837	69.394	86.896	82.823
Netherlands	13.857.525	14.046.559	13.810.632	13.540.086	13.700.116	14.447.063	13.385.540	12.613.498	11.849.496	14.282.654
Poland	3.660.396	3.612.124	3.967.639	4.637.314	5.096.527	4.897.642	4.991.067	6.258.324	7.298.580	6.994.911
Portugal	1.372.382	1.432.050	1.183.043	1.196.392	1.237.188	1.015.643	1.041.758	1.203.624	1.379.336	1.522.175
Romania	1.248.701	1.835.288	2.029.312	2.179.360	2.511.023	2.724.782	2.494.181	2.795.944	3.199.497	3.167.276
Slovakia	110.078	321.225	302.122	223.966	208.819	216.491	124.814	217.052	266.363	186.650
Slovenia	1.453.871	1.375.547	1.440.627	1.241.639	1.279.871	1.340.756	1.452.620	1.453.084	1.453.878	1.429.980
Spain	7.926.591	8.387.070	7.503.613	7.804.988	6.793.233	8.161.356	8.100.173	7.160.575	8.960.598	9.693.958
Sweden	2.747.794	2.601.725	2.736.100	2.973.392	2.596.502	2.443.031	2.397.403	2.801.691	2.674.701	2.751.436

Appendix 7. Material import dependency in the EU-27 Member States, 2016–2025

Dataset: Material import dependency [env_ac_mid]										
Time frequency: Annual										
Materials: Total										
Unit of measure: Percentage										
TIME	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
EU-27	24,1	24	24,2	23,7	22,2	22,5	23,5	22,6	22,6	22,1
Austria	43,2	44,4	44,6	44,6	44,4	43,2	42	42,1	41,3	40,5
Belgium	72,8	71,9	72,6	72,3	72,1	72,8	74,7	75,3	76,8	76
Bulgaria	16,1	16,8	15,7	16,4	16	15,3	17,3	15,8	16,9	17,2
Croatia	31	31,8	31,4	32,7	33,8	35,5	36,8	36,6	38,8	38,4
Cyprus	33,6	33,3	34	31,4	32,4	31,9	31,1	32,3	33,2	38,2

Dataset: Material import dependency [env_ac_mid]										
Time frequency: Annual										
Materials: Total										
Unit of measure: Percentage										
TIME	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Czechia	32,3	32,9	32,8	32,7	31,1	33,2	32,9	34	34,6	34,2
Denmark	36,5	36,6	38,7	37,5	38	39,2	39,6	40,8	40,6	39,3
Estonia	22,5	21,1	23,6	24,6	26,9	30,5	26,4	22,2	21,7	22,1
Finland	21,2	20,7	21	21,7	20,2	19,2	18,1	17,1	17,7	16,9
France	37,4	35,9	36,1	35	34,6	31,2	32,5	30,9	31	30,9
Germany	39,9	39	39,7	41,2	39,4	38,5	38,5	38,4	38,7	39,7
Greece	32,5	33,8	35,5	36,2	39,2	40,7	40,3	39,9	41,4	37,4
Hungary	28,1	29,6	29,5	27,1	26,8	27,9	29,7	27,6	28,1	27
Ireland	30,2	30	30,8	28,6	29,3	31,3	30,6	30,3	32	33
Italy	47,5	49,2	49,2	48,3	45,7	46,6	48,1	46,9	46,8	47,1
Latvia	32	30,5	32,9	31,5	32	31,4	31,1	32,3	31	32
Lithuania	40,4	39,2	41,4	40,5	36,7	37,9	36,8	34,7	34,9	34,8
Luxembourg	90,9	91,4	91,2	91	90,2	89,4	90,1	89	87,5	88,3
Malta	75,4	77,1	75,2	70,8	69,9	72,5	72,5	74,5	78,3	77,1
Netherlands	78,1	77,7	79,2	79,7	79,8	81,4	81,9	82,7	83,4	83,4
Poland	17,8	18,1	19,5	19,5	19,3	19,7	20,8	20,5	19,8	19,7
Portugal	32,1	31,2	31,5	31	30,9	28,6	31,9	31,2	32,3	32,1
Romania	10	10,8	10,7	9,5	9,3	10,1	9,9	9,2	9,5	8,6
Slovakia	42,5	42,9	43	44	42,7	45,2	45,8	43,8	44,4	42,7
Slovenia	47,5	47,7	47,1	48,4	46,5	45,6	47	46	48,5	48,8
Spain	43	45,8	43	41,9	38	39,5	42,3	41,5	39,9	37,2
Sweden	26,4	25,5	26,8	25	23,7	23,9	24,4	24,6	25	23,6