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A dynamic Material Flow Analysis of furniture in the EU27 to support future circular strategies

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Abstract

Circular Economy strategies require robust analyses of material stocks and flows of relevant product groups. Furniture is one such relevant product category, yet its stocks and flows remain poorly quantified. This study addresses this gap by conducting a dynamic Material Flow Analysis at the product and country level in the European Union (EU27) from 1995 to 2024. A robust data cleaning and gap filling framework is developed to refine production data from the Eurostat PRODCOM database, while explicitly addressing uncertainty through the estimation procedure using a Monte Carlo approach. Combining production with trade data from BACI, we calculate in each EU27 country yearly consumption, stock, waste generation, and estimate composition for 19 furniture product categories. In 2024, EU27 furniture stocks reached 231 Mt (515 kg/capita) with wooden furniture products accounting for the largest share. Of the 19.4 Mt of waste generated, preliminary estimates suggest that in the EU 60% is recycled, 33% incinerated, and 7.5% landfilled.

1. Introduction

Circular Economy (CE) is a concept that promotes resource efficiency by reducing the use of material products, extending the lifetime of products, maximizing the reuse and recycling of products and materials, and thereby minimizing waste (Ellen MacArthur Foundation, 2013; Stahel, 2016). Therefore, CE decreases environmental pressures while maximizing the utility of extracted resources (Alnafrah et al., 2025; Mhatre et al., 2021). For these reasons, the European Union (EU) has prioritized CE, introducing action plans to reduce waste and improve resource efficiency, such as Ecodesign for Sustainable Products Regulation (ESPR) and Extended Producer Responsibility (EPR) (Alnafrah et al., 2025; De Pascale et al., 2023; European Commission, 2015, 2020; Mhatre et al., 2021). These policies focus on resource-intensive sectors and materials, including construction, waste management, electronics, and plastics (European Commission, 2020). Recently, textiles and furniture have also emerged as priority sectors in CE policies (European Commission, 2020; Mhatre et al., 2021). Notably, furniture is among the eleven ESPR priority products (Faraca et al., 2024) and is the focus of this study.

Furniture is a key manufacturing sector in the EU, generating €37 billion in value added in 2023, equal to 0.2% of EU GDP (Eurostat, 2025b, 2026b). Across 130 thousand enterprises, it employs over 900 thousand people (3% of EU manufacturing workforce) and accounts for 28% of global furniture production (Eurostat, 2025b; Faraca et al., 2024; Forrest et al., 2017). This major industry is characterized by high material intensity, driving most of its environmental impact. In fact, furniture is among the largest forest-based industries due to its high demand for wood. Adhesives and textiles also contribute to its significant footprint (Azizi et al., 2016; European Commission, 2013; Pei et al., 2024; Yang et al., 2025). Life Cycle Assessment (LCA) studies have calculated emissions from different furniture items over their lifetimes. These range between 6–30 kg CO_2-e per seat, 40–140 kg CO_2-e per item of office furniture, and 120–130 kg CO_2-e per item of kitchen furniture (Linkosalmi et al., 2016).

The economic and environmental significance of the furniture sector underscores the need for CE policies to optimize resource use. Despite this, CE research on furniture remains scarce compared to other sectors (Kulakovskaya et al., 2024). The few existing studies on circularity for furniture predominantly focus on sustainable product design of individual items (Bianco et al., 2021; Faraca et al., 2024; Lanoë et al., 2013; Pei et al., 2024; Yang et al., 2025). However, product-level focus is insufficient for CE policy development (Losa, 2025). These policies require a structured, quantifiable assessment of the stocks and flows of furniture products and materials within the EU, because effective CE interventions require a thorough understanding of how furniture materials accumulate and become waste in the system (Leipold et al., 2023; Rostek & Loibl, 2025). In fact, similar

assessments already exist for product groups relevant to the EU CE strategy, including electronics, plastics, and textiles (Amadei et al., 2022; Hsu et al., 2021; Lase et al., 2023; Napolano et al., 2025; Pauliks et al., 2026). Moreover, stocks and flows analysis is a precondition for subsequent assessments, including LCA and macro-economic modelling to quantify the environmental and socio-economic effects of circularity measures in the sector, as demonstrated in other CE-relevant industries (Albizzati et al., 2025; Damgaard et al., 2022; Milios et al., 2025; A. Wagner et al., 2025; Walker et al., 2025).

Only a limited number of studies have attempted to estimate furniture stocks and flows, and these efforts are limited in scope or in methodological robustness. Krych and Pettersen (2021) estimated the furniture stock of Norway using furniture density (average kilograms of furniture per unit floor area) combined with total building floor area. Later, Wiprächtiger et al. (2022) calculated furniture stock in Switzerland using average furniture ownership per capita. While both these methods provide rough approximations, they depend on generalized averages that are not representative enough to provide a robust, time-, and product- explicit stock calculation.

In contrast, Wagner et al. (2022) applied a more data-driven approach for Germany, calculating stock from consumption statistics and estimates of average furniture lifetime. Consumption was calculated using PRODCOM data. PRODCOM (from French PRODuction COMmunitaire or Community Production) is the annual EU survey collecting national statistics on volume and value of production of manufactured goods (Eurostat, 2023). The database contains external trade data from Comext too (Eurostat, 2026g). Wagner's methodology follows from the most cited study for furniture flows estimation by Forrest et al. (2017) on the EU28. Commissioned by the European Commission, Forrest's analysis estimates furniture consumption and waste generated to evaluate the impact of CE furniture policy scenarios. The study remains a key reference even in recent studies in the field, highlighting the strong interest in these kinds of analyses (Barbaritano et al., 2019; Dokter et al., 2023; Russell et al., 2023; van Hees et al., 2025; Yang & Vezzoli, 2024). However, similarly to Wagner et al. (2022), the study by Forrest et al. (2017) is constrained by significant data limitations, as inconsistencies and gaps in the PRODCOM database are not addressed robustly, thereby reducing the accuracy of results. Additionally, Forrest's study lacks a direct calculation for furniture stock amounts and relies on limited sources for the estimation of furniture weights and waste production.

Therefore, a recent, comprehensive, and methodologically rigorous assessment of furniture stocks and flows across the EU27 is still lacking. We address this gap by conducting a dynamic Material Flow Analysis (dMFA) of furniture across EU27 Member States, considering both stand-alone furniture items and mattresses (hereafter collectively referred to as "furniture") for a total of 19 products. Another contribution of this study is that, unlike e.g. Forrest et al. (2017), we develop and apply a comprehensive data cleaning and gap filling methodology to improve the quality and reliability of PRODCOM-based estimates.

2. Materials and Methods

This section describes the methodology for quantifying furniture stocks and flows (Fig. 1). We define the system boundaries (2.1), and describe the calculation of annual consumption (2.2) for 19 furniture products in the EU27 countries from 1995 to 2024. Using product lifetime estimates, we calculate country stocks of the 19 furniture products from 2015 to 2024 (2.3), and calculate annual waste generation per country and use material composition to determine end-of-life treatment (2.4).

2.1 Scope and system boundaries

This study considers finished furniture products consumed by both private households and businesses in the EU27 members from 1995 to 2024. Product categories are selected based on the PRODCOM and Harmonized System (HS) classifications of goods, headings 31 and 94 respectively, to ensure a harmonized and internationally recognized categorization of furniture (European Commission, 2022; World Customs Organization, 2022). We exclude furniture parts, which are production intermediates, not finished products. Overall, we account for 19 furniture categories, a comprehensive list is available in the Supporting Information (SI1).

2.2 Consumption data calculation

Consumption *C* of each furniture product category *p* was calculated from import *I*, export *E*, from and to all regions *r*, and production *P* for each country *c* in the EU27 for every year *t* from 1995 to 2024 in both euro and kg.

$$C_{t,c,p} = P_{t,c,p} + \sum\nolimits_{r} I_{t,c,p,r} - \sum\nolimits_{r} E_{t,c,p,r}$$

Import and export data are obtained from the BACI database, which provides high quality, harmonized, yearly, product-level trade data in USD and kg from 1995 to 2024 for 200 countries and 5000 products, including the EU27 countries and the 19 furniture products under scope (Gaulier & Zignago, 2010). BACI was chosen over Eurostat Comext and UN Comtrade, as a source for trade data, due to its improved data quality and completeness (Gaulier & Zignago, 2010). In fact, multiple studies have identified limitations in Comext and Comtrade and consider BACI a more reliable alternative. (Chen et al., 2022; Nakajima et al., 2018; Napolano et al., 2025; Tercero Espinoza & Soulier, 2016).

EU furniture production data is only available from the PRODCOM database. We use the *Sold production* indicator which reports in value (Euro) and number of items, the amount of furniture items produced and sold in each EU27 country from 1995 to 2024. To calculate consumption, production and trade were converted to common units. Trade was converted from USD to Euro using the average annual exchange rates (European Central Bank, 2026), and physical amounts of production were converted to kg using average weights per product category retrieved from LCA studies and furniture retail data (Hoxha & Jusselme, 2017; Lanoë et al., 2013; Wang et al., 2016; Yang et al., 2025). Weights are provided in SI1.

However, several limitations exist for the use of PRODCOM due to missing data, confidential data, and outliers (Amadei et al., 2022; Huisman et al., 2017; Napolano et al., 2025). Confidential data are explicitly flagged by PRODCOM, whereas missing data arise when only one unit (euros or physical quantity) is reported. If neither unit is reported and no confidentiality flag is present, we assume zero production for that product in that country that year. Because of these limitations, before calculating consumption and converting production to kg, production data undergoes a data cleaning procedure described below.

2.2.1 Data cleaning

The process is divided into 5 steps (Fig. 1). Technical details are available in the SI1.

STEP 1: UNIT PRICE – estimate missing data in number of items

Euro values are deflated to the same base year (2015) using furniture specific inflation indices (Eurostat, 2026c). A unit price (UP) is calculated for every product in each country every year. Missing physical quantities are imputed by fitting a Huber regression line through the yearly UP values of the given product in the country. Huber regression is used because it is not sensitive to outliers (Huber, 1964; Pauliks et al., 2026). The regression on yearly UP values

provides an imputed UP for the missing year. We divide this by the known euro value to recover the missing physical quantity. We estimate number of items from euro values and not the other way around, because monetary data is considered more reliable (Chen et al., 2019, 2022).

STEP 2: PRODUCTION TO EXPORT RATIO – estimate confidential data in euro

Following the example from Huisman et al. (2017), confidential data is estimated from export data, because export amounts are considered a good proxy for production volumes (Saltarelli et al., 2020). The yearly production-to-export ratios are calculated for each product in each country in euros. If the euro value for a given product and country is confidential, and therefore not available, Huber regression through the yearly production-to-export ratios is used to estimate the missing ratio. From the new estimated ratio and reported export value for that year, the confidential monetary amount is calculated. Step 1 is then repeated to get from the new euro value the number of items.

STEP 3: MEDIAN ABSOLUTE DEVIATION & RESIDUALS – identify outliers

Outliers are identified following the examples from Huisman et al. (2017) and Napolano et al. (2025). Both methods are applied to the yearly production values in physical units and euro, at the country-product level. The Huisman et al. (2017) method uses Median Absolute Deviation (MAD). For this study we adapted it with a rolling 5-year window, meaning outliers are detected relative to nearby years rather than the full time series. Extreme values, relative to the whole time series, are then identified using the residuals method proposed by Napolano et al. (2025). Values flagged by either method are removed.

STEP 4: LINEAR INTERPOLATION – estimate missing data in euro

Ordinary Least Square (OLS) linear interpolation is used to fill gaps in the monetary time series (yearly production values for one country and one product). To preserve production trends, OLS is based only on the two nearest observations before and after each missing value, rather than the full time series. Step 1 is then repeated to calculate the physical values from the newly estimated monetary values.

STEP 5: AGGREGATED RATIO & INTERPOLATION – estimate remaining missing data

Remaining missing observations are estimated with aggregated approaches. We repeat the previous steps using aggregated data to estimate missing UP and export-to-production ratios. OLS interpolation is also reperformed on the physical values.

Of all the data points (317,773 in total), 6,426 were missing or confidential (2.02% of the total). Our procedure imputed 9,746 values, after removing an additional 3,398 outliers. After the five steps, only 72 observations (0.023% of the total) remain undetermined and left blank.

2.2.2 Uncertainty

Given the high number of estimated values, uncertainty is quantified. Regression steps (Huber or OLS) are implemented with stochastic regression imputation (Fig. 1). That is, when data is fitted with Huber or OLS, the variance of the residuals is calculated. Then, missing values are drawn from a normal distribution with the same variance and centered on the value predicted by the regression (Thongsri & Samart, 2022). Using a Monte Carlo simulation, we repeat the five-steps 500 times to obtain 500 production datasets with slightly different estimations.

We also consider uncertainty in the conversion from number of items to kg because for each furniture category there is a range of possible weights (e.g. the category wooden furniture for the bedroom includes furniture items of widely different weight ranges). For each of the 500 production dataset resulting from the data cleaning, we draw a weight conversion factor per product category from a normal distribution of weight range. So, for each production dataset, slightly different weights are used to convert to kg. This approach samples from the joint uncertainty of production estimations and weight ranges where the full distribution of results is captured across the ensemble of simulations. Doing so, we also avoid nested simulations (i.e. repeated sampling of the weight distributions on each production dataset) while still sampling from the whole uncertainty space (Fig. 1).

2.3 Stock calculations

To calculate the stock, furniture lifetime data is needed. Following standard dMFA modelling, lifetime is expressed as a Weibull function, a probability distribution that describes the lifetime or failure behavior of products over time (Müller et al., 2014). For each product category, its Weibull distribution is defined by scale (λ) and shape (k) parameter. The scale λ is derived from the average lifetime of items within each furniture category. Due to limited data on furniture, the shape parameter k, which captures variation in lifetimes within a product category, is approximated using white goods as a proxy, as proposed by Wiprächtiger et al. (2022). Weibull parameters are provided in the SI1. The resulting lifetime curves are assumed to span the entire life of the items, from initial purchase to final disposal, encompassing any intermediate second-hand cycles the items may undergo in the current situation.

For product *p* in country *c*, the stock *S* in year *t* is calculated as the sum of the consumption *C* in year *t* plus the remaining products from previous years.

$$S_{t,p,c} = C_{t,c,p} + \sum_{a=1}^{t-t_0} C_{c,p,t-a} \cdot \left(1 - W_{\lambda,k}(a)\right)$$

$W_{\lambda,k}$ is the cumulative distribution of the Weibull lifetime curve, representing the share of products p discarded as waste at age a.

Both consumption and stock are calculated 500 times from each of the production dataset, therefore propagating the uncertainty from production estimation and conversion to kg.

2.4 Waste

Waste amounts are calculated from furniture items leaving the stock based on their lifetimes. However, since statistics on waste treatment in the EU are only available at the material level, to calculate how furniture waste is treated, we developed a proxy approach.

First, we determine the average material composition of each furniture category. We determine composition of sample products for each category from LCA studies and Environmental Product Declarations (EPDs) (Hoxha & Jusselme, 2017; Lanoë et al., 2013; Yang et al., 2025). The detailed materials are aggregated into macro categories (e.g. wood, plastic, textile). The material database is available in SI2.

In the EU, furniture is discarded in Municipal Waste (MW) (Directive (EU) 2018/851 on Waste, 2018). The wooden fraction of furniture is separated to be treated within non-hazardous wood waste (Ikenze et al., 2024). Additionally, since 2021 EU countries report the products in MW that are Prepared for Reuse (PfR), among which furniture (Costa et al., 2024; Implementing Decision (EU) 2021/19, 2020). Additionally, since 2021 EU countries report the

products in MW that are Prepared for Reuse (PfR), including furniture (Costa et al., 2024; Implementing Decision (EU) 2021/19, 2020). PfR does not refer to the products that are reused before being thrown away. Rather, it represents products that have entered the waste stream and are subsequently checked, cleaned, or repaired.

Therefore, once furniture is discarded it ends in MW, part is prepared for reuse and reintroduced into the market (Planells et al., 2025), while the wooden fraction is sent to the wood waste flow, and the rest is treated as part of the MW. To determine fate of furniture waste then, we start by calculating the percentage of MW sent to PfR each year in each country from Eurostat data and use this percentage as proxy of the share of furniture going to PfR after being discarded (Eurostat, 2026d). Then, we take the amount of MW collected in each country and year minus the organic fraction and calculate the percentage going to each treatment operation (e.g. recycling, landfilling, incineration) (Eurostat, 2026d). We assume the non-wood fraction of furniture waste follows on average the same shares. For example, if 20% of non-organic MW is landfilled, the same share is assumed for non-wood furniture waste. Similarly, we use Eurostat data to determine the share of total wood waste allocated to different treatment operations (Eurostat, 2025d). These percentages are used as proxies to estimate treatment. Missing yearly data in the waste treatment database is estimated using Huber regression.

3. Results

Because our first year of analysis is 1995, and no opening stock data is available, stock results become robust from 2015 given typical furniture lifetimes (15–20 years). However, as the most recent year in our analysis, we mostly report results only for 2024 or the 5 years prior. Results for the full year range are available in SI1.

3.1 Import, export, production, and consumption

In 2024 the value of EU countries' furniture import totaled €40.7 billion and export €43.0 billion, respectively. The use of the BACI database allows us to detail the trade partners. We see that in value, 59.7% of imports came from other EU countries, and that overall, the EU27 area exported abroad €15.0 billion and imported €17.3 billion in 2024, making the EU a net importer. This contrasts with what is seen in Forrest et al. (2017) where the EU is calculated to be a net exporter, this discrepancy is likely attributable to the lack of detail in trade partners and trade balance in PRODCOM which was the only database considered in their analysis (Eurostat, 2023). In 2024 the top total exporters were Poland (€9.06 billion), Italy (€7.87 billion), and Germany (€6.72 billion) and the largest importers Germany (€9.82 billion), France (€7.043 billion), and the Netherlands (€4.71 billion). This was true for the 5 years prior to 2024 as well.

Total furniture production value in 2024 was €69.5 billion corresponding to 17.4 Mt of furniture produced in the Union. Production climbed from 20.8 Mt in 2019 to 22.4 Mt in 2021 to then start to decrease to 22.4 Mt and 18.1 Mt in 2022 and 2023 respectively. These calculations match a contraction in the sector observed by other analyses (CSIL, 2024). The largest producers in 2024 are the same as over the previous 5 years: Germany (€15.01 billion and 2.59 Mt), Italy (€13.5 billion and 2.50 Mt), and Poland (€10.1 billion and 4.17 Mt).

During 2021 and 2022, total furniture consumption in the EU27 exceeded €70 billion, followed by a dip in 2023 (€69.7 billion) and a rise in 2024 to €71.8 billion, equal to a yearly average per capita consumption of €159.8 or 44.4kg in 2024 (Eurostat, 2026e). The highest per capita consumers in 2024 were the Netherlands (€298 per capita), Ireland (€297 per capita), and Luxemburg (€293 per capita). The smallest consumers per capita were Slovakia, Greece, and Lithuania (€77.8, €76.8 and €42.2 per capita respectively). By mass the highest per capita

consumers were Ireland, Denmark, and Lithuania (117 kg, 101 kg, and 93.9 kg respectively) and the lowest Greece, Romania, and Slovakia (24.5 kg, 20.3 kg, 19.7 kg respectively). In terms of furniture products, the highest consumed category in value is wooden furniture items not intended for the office or the bedroom (€16.7 billion in 2024), followed by kitchen furniture (€12.6 billion), non-office metal furniture (€7.26 billion), upholstered seats with wooden frames (6.63 billion euros), and wooden furniture for the bedroom (€5.56 billion). For future CE policies, physical amounts are important to note as they correlate to waste amounts and resource demands. The most consumed products in 2024 by weight are wooden furniture items not intended for the office or the bedroom (5.49 Mt), followed by wooden bedroom furniture (3.25 Mt), non-office metal furniture (2.00 Mt) and kitchen furniture (1.96 Mt). Detailed import, export, production, and consumption data are available in SI3.

3.2 Stock

Most furniture in stock is produced within the EU27 (Fig. 2). In 2024, the whole EU27 furniture stock amounted to 231 Mt (515 kg per capita), it has increased by an average of 2.8 Mt per year since 2015. We do not distinguish between residential and business furniture since this detail is missing from input data.

The biggest shares of furniture by mass are the wooden furniture categories (Fig. 3). Overall, there are no significant trends in stock change across categories. We can, however, observe a decreasing trend for categories such as office furniture (metal and wood), while under uncertainty, wooden furniture categories in stock have increased. Stock breakdown is important as it allows us to understand what material resources are expected to reach the waste stream in the EU and trends in stock allow us to estimate future resource demands, which are both aspects of great importance for CE policy.

In our analysis we consider mattresses together with the other furniture items, in 2024 the stock of mattresses is estimated at 14.4 Mt of which 31.2% cellular mattresses (foam and latex). To validate our results we compare to the estimations done by Wagner et al. (2022). They calculated mattresses in Germany based on number of beds in hospital, hospitality, and long-term facilities, and population numbers plus people having a second home and minus percentage reporting not sleeping on mattresses. They calculate 80.7 million mattresses in Germany in 2017. Considering an average weight of 20kg for a cellular mattress and 31kg for the remaining mattress types, our stock estimates for mattresses in Germany in 2017 is 85.1 million, roughly a 5% difference. We repeat this calculation for the EU in 2024 as an additional validation, our stock assessment calculates 542 million mattresses. Given the number of beds in hospitality (Eurostat, 2026a), hospitals (Eurostat, 2025c), and long-term care facilities (Eurostat, 2025a), the EU population (Eurostat, 2026e), second house ownership (Wind et al., 2020) and assuming the same share estimated by Wagner et al. (2022) does not sleep on a regular mattress, this yields 512 million mattresses, a difference of 4% compared to our stock estimation. Overall, the small differences between independent estimation approaches support the robustness of our stock estimates.

3.3 Material composition and waste management

From the stock results, we calculate yearly furniture waste generated in the EU27. We find that furniture waste in the EU increased steadily between 2015 and 2024, averaging 18.4 Mt annually and reaching 19.4 Mt in 2024. This corresponds to a yearly average (from 2015 to 2024) of 41.0 kg of furniture waste per capita in the EU27. Based on statistics on total MW per country per year we see that furniture waste makes up 8% of MW on average (Eurostat, 2026d). Because in our analysis waste is calculated only based on consumption and lifetime of furniture, the biggest waste generators coincide with the largest consumers.

We find that wood represents the largest material contribution to furniture (Fig. 4). The major wood types we were able to identify based on product declarations, are Medium-Density Fiberboard (MDF) (29% of total wood), timber (21%), and particle board (8%), to note that many do not declare the type of wood employed so 32% of wood is of unspecified type. Most of the metal employed in furniture is steel (88% of total metal) with smaller percentages of aluminum (5%), of the total metal 6% is of unspecified type. Plastic use in furniture is prevalent, especially in upholstery. The largest polymers used are PUR, PP, PVC, PET (35%, 10%, 8%, and 8% of total plastic makeup respectively).

For waste treatment, we estimate that most of the furniture is recycled or incinerated with energy recovery, while smaller percentages are incinerated without energy recovery and landfilled (Fig. 4). This is an average, and it must be noticed that some EU countries still rely heavily on landfilling. While it is challenging to estimate furniture amounts prepared-for-reuse as reporting on this flow is new, we calculate this to be 0.3% of total furniture waste based on currently available data (Eurostat, 2026d).

Besides EU averages, country level data (Fig. 4) reveals that many countries rely significantly on landfilling. In our study we estimate that in percentage of furniture waste the biggest landfillers in 2024 are Malta (85% of furniture waste to landfill), Cyprus (48%), Greece (33%), Bulgaria (29%), and Romania (29%). Those that recycle most of the furniture waste are Luxemburg (89%), Latvia (83%), Italy (76%), Austria (76%), and Slovenia (73%). The full results are available in SI3.

4. Conclusion and recommendations

This study presents an assessment of furniture stocks and flows in the EU27 at the product and material level to offer a data baseline for the development of future EU CE policies in the furniture sector. Adopting a dMFA approach, we use trade and production data to determine the yearly stock per country of 19 furniture product categories. We then quantify material composition, waste amounts, and treatment.

Our study develops a comprehensive analysis that combines PRODCOM production data with BACI trade data to calculate apparent consumption and stocks at a detailed country and product level for the whole EU27. Additionally, we explicitly address data quality issues in PRODCOM through a dedicated data cleaning pipeline with uncertainty propagation. Earlier studies estimated furniture stocks using simplified proxies such as floor area or average furniture per capita (Krych & Pettersen, 2021; Wiprächtiger et al., 2022), or relied on PRODCOM data without systematically treating missing values, confidential observations, and outliers (Forrest et al., 2017; Wagner et al., 2022). Our approach provides a replicable framework for robust data treatment that can likely also be applied to future research on other products relying on PRODCOM or similar databases.

Our second contribution is the results of our analysis. These also extend beyond the existing literature by providing a product- and country-specific quantification of furniture consumption, stocks, and material composition across the EU27. We estimate 231 Mt of furniture stock and annual waste generation of 19.4 Mt in 2024, with wood-based products accounting for the largest share of accumulated materials. Before, the main furniture study at the EU level was Forrest et al. (2017). Their work mostly focuses on furniture consumption without directly establishing a stock calculation approach while in our study we use dMFA to provide detailed stock calculations. Together, our findings establish an updated baseline of furniture stock in the EU27.

Our methodology explicitly incorporates uncertainty through stochastic imputation and Monte Carlo simulations, propagating uncertainty from production estimates into the final stock results. Nevertheless, several uncertainties

remain. The amount of furniture waste generated is calculated with the use of proxy lifetime curves. We use product-specific data on lifetime to improve accuracy; however, future efforts in directly measuring lifetime dynamics at the product and country-level will strengthen these estimates. The largest limitation of our model lies in the estimation of waste treatment pathways. Due to the absence of furniture-specific waste statistics, we use countries' yearly average waste treatment statistics. Because furniture waste ultimately is treated within these streams, we assume this provides a reasonable approximation of furniture end-of-life. While detailed reporting of furniture waste treatment may provide additional granularity, the fate of the individual material fractions composing the furniture will remain unknown, as the materials are sorted and further treated in separate plants. This is an outstanding limitation that future studies should investigate.

Overall, despite these uncertainties, the results provide a baseline for circular policy analysis of the furniture sector in the EU. The substantial countries' differences in waste treatment indicate that policy should go beyond aggregate EU data and account for the considerable variations among member states. Local markets, notably for wood and waste-to-energy, are likely to play a role in the material-specific recycling rates. Analysis of the material composition of the furniture stock also provides key insights. Firstly, we can determine material demand and potential material recovery in the sector. Secondly, material data provides a basis to investigate the changes in environmental impacts because of new design developments, providing key information to inform future implementing legislation under the EU ESPR umbrella.

Declarations

Conflict of Interest Statement:

The authors declare no conflict of interest.

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Author Contribution

Based on the CRediT system:R. B. (Conceptualization, Methodology, Data analysis, Writing - Original Draft, Data Curation, Investigation, Formal analysis, Validation)R. H. (Conceptualization, Writing - Review & Editing, Supervision, Project administration)D. T. (Conceptualization, Writing - Review & Editing, Supervision, Project administration)A. T. (Conceptualization, Writing - Review & Editing, Supervision, Project administration, Funding acquisition)All authors have given approval to the final version of the manuscript.

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Data Availability

All data supporting the findings of this study are available within the paper and its Supplementary Information. Raw data is provided in SI3 while the weights and the composition of the products under consideration are available in SI1 and SI2 respectivley. The original data used to obtain results is also publicly available from the Eurostat data repository referenced in the article. The methodology to obtain additional data is detailed in the article and in SI1.

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Figures

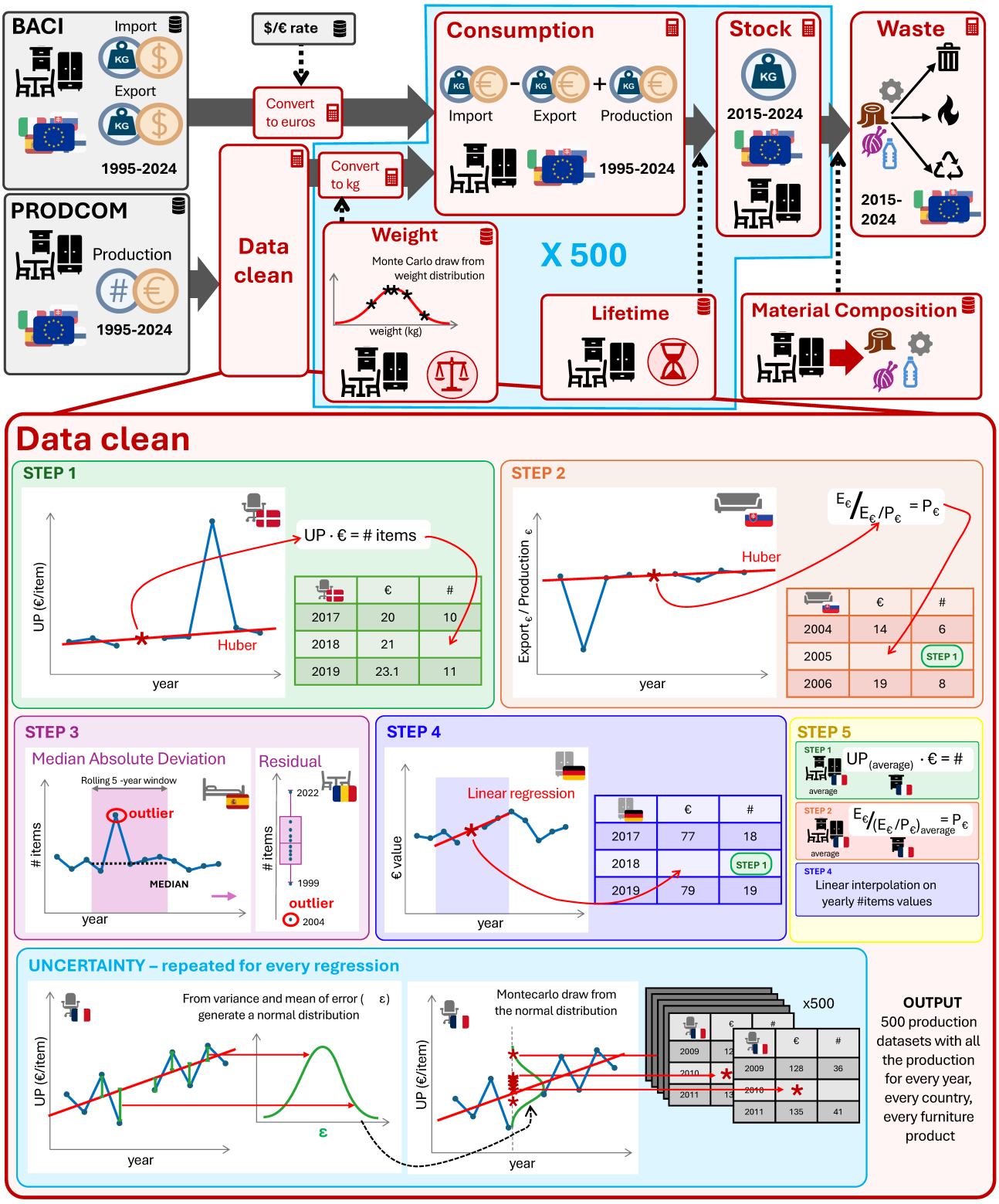


Figure 1

Methodology to calculate furniture stocks and waste treatment including data cleaning.

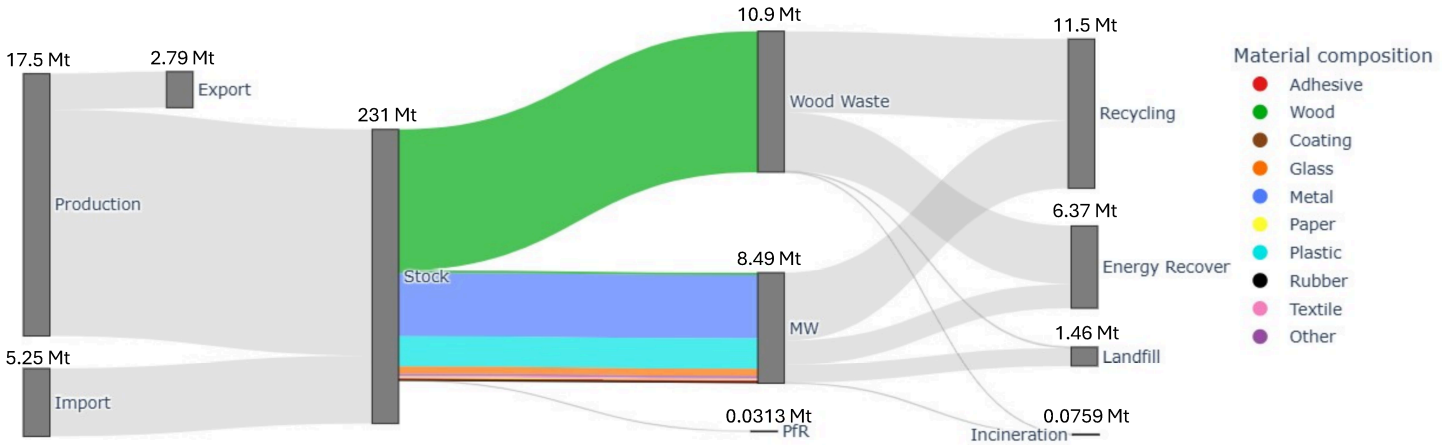


Figure 2

Sankey diagram of furniture MFA for EU27 in 2024.

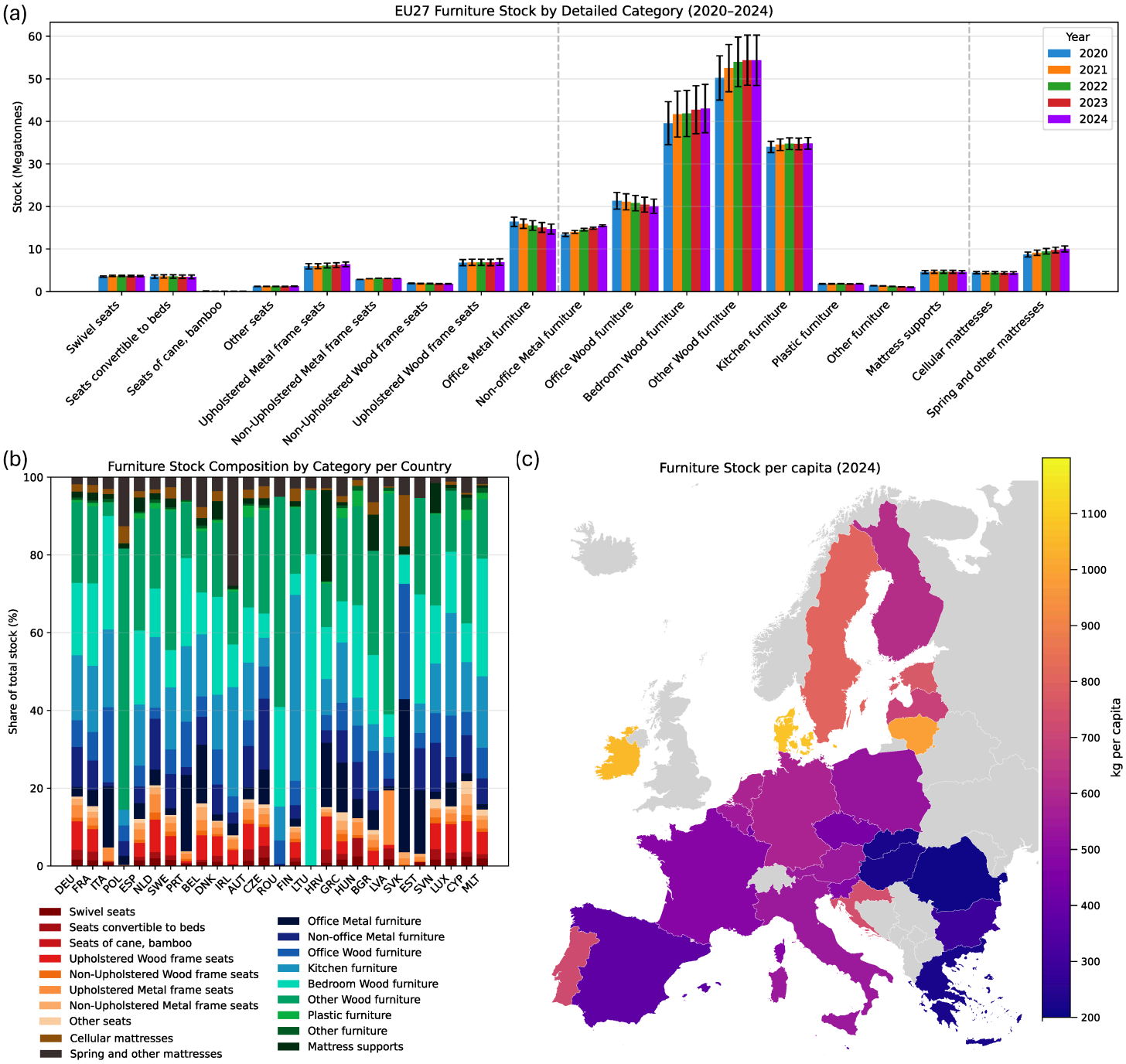


Figure 3

Overview of furniture stock results. On top, the total stock in the EU27 from 2020 to 2024 for each category considered (a). Then, the country's stock breakdown by product in 2024 (b) and the total per capita stock in the same year (c).

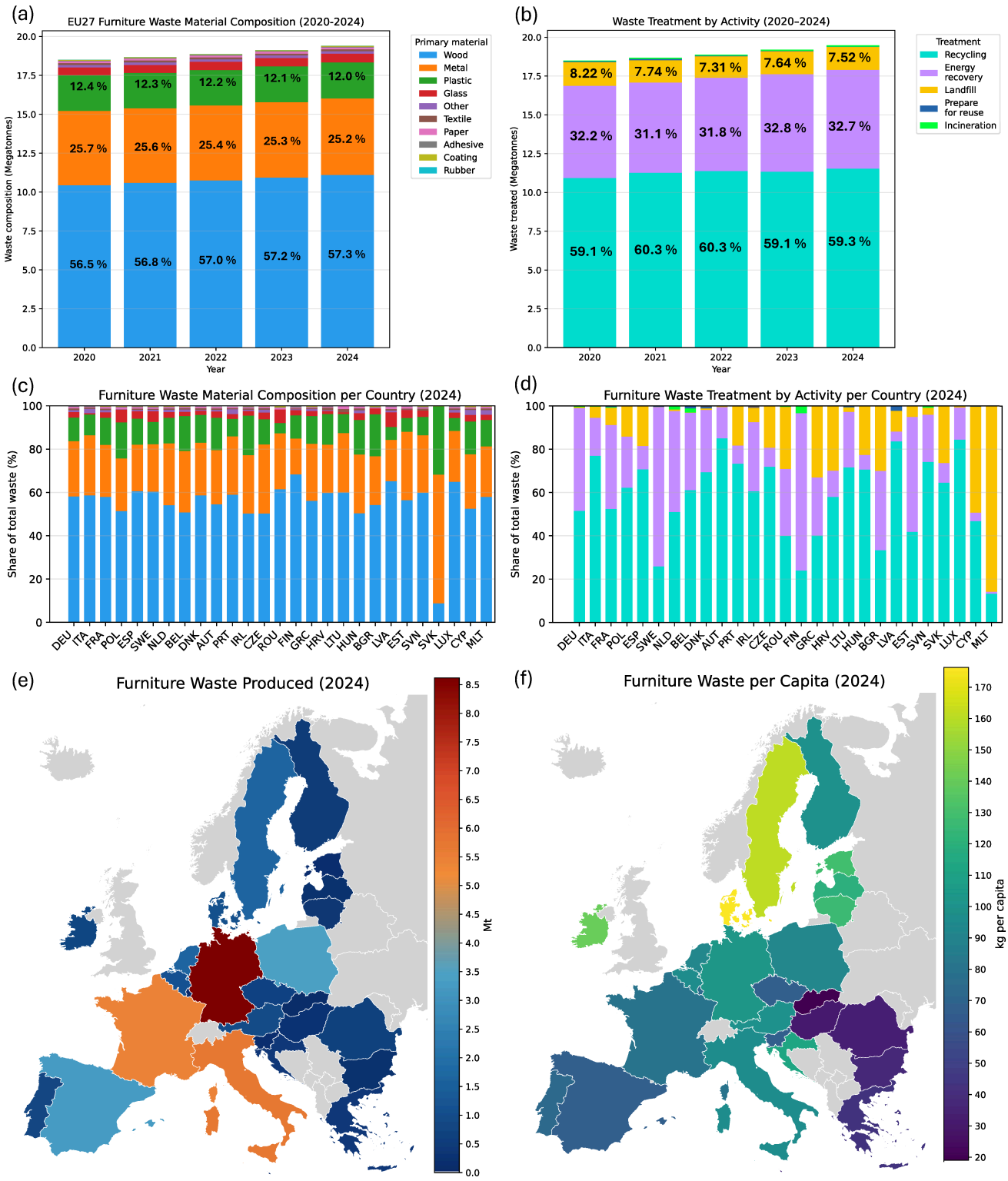


Figure 4

Overview of furniture waste results. On top, furniture waste composition (a) and treatment (b) in the EU27 from 2020 to 2024. Below, furniture waste composition (c) and treatment (d) in 2024 per country. Finally, waste amount produced in total (d) and per capita (e). ‘Energy recovery’ means incineration with energy recovery, while ‘incineration’ means without.

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