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A 2018 Social Accounting Matrix for Germany depicting waste and recycling accounts for a circular economy

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Abstract

The 2018 SAM for Germany comprises of 160 accounts including 63 activities, 85 commodities, margins, labor, capital, household, government, social contributions, taxes on products, activity tax, direct tax, stock change, savings and investment and the rest of the world. It is entirely based on data from the Federal Statistical Office of Germany (Destatis), which guarantees the highest possible degree of data-consistency. Because the initial version of the SAM (Proto-SAM) has imbalances in the government, savings and investment and the rest of the world accounts, a balanced SAM is estimated using the cross-entropy method. To ensure the consistency of the data through the estimation process, macro totals are enforced as controls for total imports, total value-added, total private consumption, total government consumption and total exports.

Keywords: social accounting matrix, Germany, circular economy, recycling

JEL: E16, Q53

Content

List of tables

Abbreviations

ACTIVITY	Activities
ATAX	Taxes on activities
CAP	Capital
CMDTY	Commodities
DIRTAX	Direct taxes
DTAX	Direct taxes including social security contributions
Destatis	Federal Statistical Office of Germany
FCTR	Production factors
GDP	Gross domestic product
GOV	Government
HH	Household
ITAX	Indirect taxes
LAB	Labor
MRGN	Trade and transport margins
n.e.c.	Not elsewhere considered
o.o.	Without a distinct focus
SAM	Social Accounting Matrix
TAXOP	Taxes on products
SCH	Stock changes
S-I	Savings and investments including stock changes
S-INV	Savings and investments
SSC	Social security contributions
TOTAL	Sum of all values
WRLD	Rest of the world

1 Introduction

The underlying rational of the economic system today lies in the linearity of the creation of goods through the process of take, make, use, dispose and pollute. However, this concept is not sustainable for the future because it causes scarcity of finite resources and health problems for people exposed to waste. In a circular economy, waste is considered as an input factor to produce new goods, which minimizes the extraction of additional resource and keeps the resources in the cycle for longer periods (Mohajan, 2021). There are countries picking up the idea of a circular economy like China, Japan and Canada, however, in Germany there is no concise plan with respect to that (Weber & Stuchtey, 2019).

To analyze the potential of the circular economy in Germany, we developed a Social Accounting Matrix (SAM) for Germany depicting the economy in 2018 with a special focus on the waste and recycling sector. A SAM captures the monetary transactions within an economy among suppliers and consumers of goods and services and other institutions. In a SAM, expenditure and income for each account must equate (Breisinger & Thurlow, 2009).

This paper is divided into four sections and the remaining parts of it are structured as follows: Section 2 describes the practical approach adopted throughout the process of developing the SAM and the used data sources, Section 3 depicts the structure of the German economy in 2018 based on the SAM, and Section 4 provides final remarks summarizing the results and giving an outlook for further development.

2 Adopted approach of SAM development

Before delving in the process of developing a new SAM for Germany, we reviewed the literature in order to identify existing SAMs that could be updated and/or expanded. The obtained SAM-based publications included Kalinowska & Steininger (2009), who used a CGE model to analyze the car road charging in Germany and Austria based on a 2002 SAM, Baas & Brücker (2010), who used a CGE model to analyze the macroeconomic impact of Eastern European enlargement on Germany and the UK, Mense & Kholodilin (2011), who developed a 70-sector CGE model for Germany with a 2007 SAM and Rothe (2017), who analyzed energy related questions using a 2007 SAM. The most recent publication we found was Boehringer et al. (2021) who analyzed the impacts of emission pricing for Germany using GTAP database with the base year 2011. We contacted the respective authors requesting their databases. We were able to obtain a 2015 SAM for Germany from the authors of Baas & Brücker (2010). However, we decided not to build on the 2015 SAM because it lacked a documentation, which constrained our understanding of the underlying assumptions.

For this reason and as the other SAMs available were already quite dated, we decided to build a SAM from scratch such that we would be sure about the underlying data. Three potential data sources were consulted to develop a SAM for Germany. These are Eurostat, OECD and Destatis. The most detailed data for Germany was available from Destatis and hence, it was

our choice of data source to construct the 2018 SAM. We extracted national accounts data for 2018 (Destatis 2022 a-e) as well as an Input-Output-Table for 2018 (Destatis 2021b) as our main data input.

2.1 Development of a Proto-SAM

Based on the Destatis data, the SAM comprises 63 activities, which produce 85 commodities. Trade- and transport margins are merged into one account. Factor accounts include labor and capital. There is one representative household account, while the government is represented by an own account, together with separate accounts for social security contributions, taxes on productss, production taxes and direct taxes. Finally, there are accounts for stock changes, savings-and-investment, and rest of the world. Thus, the SAM consists of 160 accounts (Appendix 1).

In the remaining part of this subsection, the data-sources of each account of the SAM are provided and the related calculations and assumptions are described. Table 1 provides an aggregate representation of the different accounts in a descriptive Macro-SAM. Transactions in Table 1 are explained by a payment from each column to the respective row. The data sources and the dimensions of each account/transaction are provided in Table 2. This makes a reproduction or any potential update of the SAM straightforward. The sub-matrices of Table 2 have the dimensions rows (m) by columns (n). Data in both English and German language from Destatis were used with data tables in German offering a higher level of detail than those in English. For reproducibility, we provide the exact cell-names and transaction terms of the original data sources. For the German terms, English translations are added.

Table 1: A descriptive 2018 Macro-SAM for Germany

	ACTIVITY	CMDTY	MRGN	FCTR	HH	GOV	ITAX	DTAX	S-I	WRLD	TOTAL
ACTIVITY		Domestic supply									Total activity income
CMTY	Intermediate demand		Trade and transport margins		Private consumption	Government consumption			Investment demand	Exports	Total demand
MRGN		Trade and transport margins									Total margins income
FCTR	Value-added									Factor income from ROW	Total factor income
HH				Factor payments to HHs		Payment of social benefits				Remittances	Total HH income
GOV							Payment indirect tax	Payment direct tax		Taxes and contributions from ROW	Total government income
ITAX	Activity tax/subsidy	Taxes on products		Social contributions							Total indirect tax income
DTAX					Direct tax						Total direct tax income
S-I				Depreciation	Private Savings	Government Savings			Stock changes	Current account balance	Total savings
WRLD		Imports		Factor payments to ROW	HH transfers to ROW	Government transfers to ROW					Total foreign exchange outflow
TOTAL	Gross output	Total supply	Total margins spending	Total factor spending	Total HH spending	Total government spending	Total indirect tax spending	Total direct tax spending	Total investment spending	Total foreign exchange inflow	

Table 2: Data sources and dimensions of the submatrices (m x n) of the 2018 Micro-SAM for Germany

	ACTIVITY	CMDTY	MRGN	FCTR		HH	GOV	ITAX		DTAX		S-I		WRLD	TOTAL
				LAB	CAP			TAXOP	ATAX	DIRTAX	SSC	SCH	S-INV		
ACTIVITY		63x85[1]													
CMDTY	85x63 [1]		4x1[7]			85x1[1]	85x1[1]					85x1[1]	85x1[1]	85x1[1]	
MRGN		1x85[1]													
LAB	1x63 [1]														
CAP	1x63 [1]													1x1[3]	
HH				1x1[5]			1x1[2]							1x1[4]	
GOV								1x1[6]	1x1[6]	1x1[6]	1x1[6]			1x1[2]	
TAXOP		1x85[1]													
ATAX	1x63 [1]														
DIRTAX						1x1[2]									
SSC				1x1[2]											
SCH													1x1[6]		
S-INV					1x1[1]	1x1[5]	1x1[2]							1x1[4]	
WRLD		1x85[1]			1x1[3]	1x1[4]	1x1[4]								
TOTAL															

[1] Destatis (2021b), [2] Destatis (2022c), [3] Destatis (2022a), [4] Destatis (2022d), [5] Residual, [6] Shift of flow towards other account, [7] 4 negative values are transposed from the 1x85 matrix of commodities paying trade and transport margins into trade and transport margins paying commodities

Activities

All payments of activities originate from sheet 1.2 titled "Verwendungstabelle 2018 zu Anschaffungspreisen" (Use table 2018 at purchaser prices) of the input output table (Destatis 2021b). The **intermediate input** data are the payments from the 63 activities to the 85 commodities. This matrix ranges in sheet 1.2 from cell D10 diagonally to cell BN94. The **value added** consists of payments from the activities to the factors *labor* and *capital*. *Labor* receives compensations of employees "Arbeitnehmerentgelt im Inland" from the activities. The data are the values from cell D100 to BN100. *Capital* receives two payments from cells D103 to BN103 "Abschreibungen" (depreciation) plus cell D104 to BN104 net "Nettobetriebsüberschuss" (net operating surplus) from activities. The **activity tax/subsidy** originate from the cell "Sonstige Produktionsabgaben abzüglich sonstige Subventionen" (other taxes on production net of other subsidies) from D102 to BN102.

Commodities

The payments of commodities originate from sheet 1.1 "Aufkommenstabelle 2018 zu Herstellungspreisen mit Übergang auf Anschaffungspreise" (2018 supply table at producer prices with transition to purchaser prices) of the input output table (Destatis 2021b). The **domestic supply** are the payments from the 85 commodities to the 63 activities. The matrix is the transposed matrix of cells D10 diagonally to cell BN94. The **trade and transport margins** are the positive values of trade margins "Handelsspannen" from BV10 to BV94. The **taxes on products** are taken from "Gütersteuern abzüglich Gütersubventionen" (taxes on products net of product subsidies) from BW10 to BW94[1]. The **imports** are taken from "Importe" (imports) from BP10 to BP94.

Two adjustments were conducted to make the data compatible with common SAM structures. Firstly, the negative values from C35_2 "Industriell erzeugte Gase, Dienstleistungen der Gasversorgung" (industrially produced gases, gas distribution services), C45 "Handelsleistungen mit Kfz, Instandhaltung und Reparatur an Kfz" (trade services with motor vehicles, maintenance and repair of motor vehicles), C46 "Großhandelsleistungen (ohne Handelsleistungen mit Kfz)" (wholesale services (excluding trade services with motor vehicles)), C47 "Einzelhandelsleistungen (ohne Handelsleistungen mit Kfz)" (retail services (excluding trade services with motor vehicles)) were transposed into the respective cells of the payment from margins to commodities. Secondly, re-exports of 108 million € were excluded from the account C07 (ores), by deducting the value of exports from the import value to facilitate the SAM-estimation using the cross-entropy method (see Section 2.2).

[1] "Taxes on products include all quantity- or value-based taxes and similar charges payable on a good or service produced or traded. They include non-deductible sales taxes, import duties (including customs duties, excise duties and levies on imported goods) and other taxes on products (energy tax, electricity tax, tobacco tax, insurance tax, etc.)" (Destatis 2021a, p23).

Trade and transport margins

The values of the trade and transport margins are the transposed negative values of C35_2 "Industriell erzeugte Gase, Dienstleistungen der Gasversorgung" (industrially produced gases, gas distribution services), C45 "Handelsleistungen mit Kfz, Instandhaltung und Reparatur an Kfz" (trade services with motor vehicles, maintenance and repair of motor vehicles), C46 "Großhandelsleistungen (ohne Handelsleistungen mit Kfz)" (wholesale services (excluding trade services with motor vehicles)), C47 "Einzelhandelsleistungen (ohne Handelsleistungen mit Kfz)" retail services (excluding trade services with motor vehicles)), as described above.

Factors

Labor

The transaction **factor payments to households** is a residual that consists of the sum of labor income minus social contributions. The payments of to **social contributions** are taken from "Net social contributions" of the national accounts statistics (Destatis 2022c) starting from cell E24.

Capital

The **factor payment of capital to households** is calculated as a residual. It is derived as the total income of capital minus depreciation of capital and minus transfers of capital to the rest of the world. The transaction from capital to savings and investment is the **depreciation** of capital. It is calculated with the sum of "Abschreibungen" (depreciation) of the input output table 2018 from sheet 1.2 "Verwendungstabelle 2018 zu Anschaffungspreisen" (2018 use table at purchaser prices) from cells D103 to BN103 (Destatis 2021b). The capital **factor payments to the rest of the world** are taken from the national accounts data (Destatis 2022a) "Primary income to the rest of the world" of cell J7.

Households

The national accounts data did not allow for a separation of the enterprise account. Therefore, enterprises are merged within the household account. The **private consumption** originates from sheet 1.2 of the "Verwendungstabelle 2018 zu Anschaffungspreisen" (2018 use table at purchaser prices) of the input output table (Destatis 2021b). The private consumption values for each commodity are from BP10 to BP94 domestic consumption of private households "Konsumausgaben privater Haushalte im Inland" (consumer expenses of private households in Germany) plus "Konsumausgaben privater Organisationen ohne Erwerbszweck" (final consumption expenditure of private non-profit organizations) from BQ10 to BQ94.

The **direct taxes** are from the national accounts (Destatis 2022c) of cell E21 "Current taxes on income, wealth etc. by households" plus cell E22 "Current taxes on income, wealth etc. by corporates". The **private savings** are calculated as a residual of the total households income minus total households expenditure. The **transfer from households to ROW** originate from

Destatis (2022d) and are the sum of cell E33 “Current transfers by corporations” plus cell E35 “Current transfers by households” plus cell E37 “Capital transfers of corporations”.

Government

The **government consumption** originates from sheet 1.2 “Verwendungstabelle 2018 zu Anschaffungspreisen” (2018 use table at purchaser prices) of the input output table (Destatis 2021b). The values for each commodity are from cell BR10 to BR94 “Konsumausgaben des Staates” (state consumption expenditure). The **payment of social benefits** is from the national accounts (Destatis 2022c) and calculated as “Social benefits to households” from cell E51 plus “Social benefits in kind” from cell E53. The **government savings** are from the national accounts (Destatis 2022c) from cell E72 “Net lending / net borrowing”. The **government transfers to ROW** are from the national accounts (Destatis 2022d) and calculated as cell E34 “Current transfers by general government” plus cell E38 “General government capital transfers”.

Indirect taxes

The indirect tax transaction is the transfer of **taxes on products** and **activity taxes** to the government. This transaction is represented by payments of the total income of taxes on products and the total income of activity tax to the government.

Direct taxes

The direct tax transaction is the payment of the collected **direct tax** and **social contributions** to the government. It is the payment of the total revenue from direct tax and social contributions to the government.

Stock changes

The **stock changes** originate from sheet 1.2 of the “Verwendungstabelle 2018 zu Anschaffungspreisen” (2018 use table at purchaser prices) of the input output table (Destatis 2021b). The values for each commodity are from cell BU10 to BU94 “Vorratsveränderungen und Nettozugang an Wertsachen” (stock changes and net acquisition of valuables).

Savings and Investment

The **investment demand** originates from sheet 1.2 of the “Verwendungstabelle 2018 zu Anschaffungspreisen” (2018 use table at purchaser prices) of the input output table (Destatis 2021b). The values for each commodity are from “Anlageinvestitionen” (fixed investments) of cell BS10 to BS94 plus “Ausrüstungen und sonstige Anlagen” (equipment and other investments) of cell BT10 to BT94 “Bauten” (buildings). The payment from savings and investment to **stock changes** is the total expenditure of stock changes (total of the stock changes column).

Rest of the World

The **exports** originate from sheet 1.2 of the "Verwendungstabelle 2018 zu Anschaffungspreisen" (2018 use table at purchaser prices) of the input output table (Destatis 2021b). The values for each commodity are from cell BV10 to BV94 exports "Exporte". The transaction **factor income from ROW** originates from the national accounts (Destatis 2022a) from cell J6 "Primary income from the rest of the world". The transaction **foreign remittances** originate from the national accounts (Destatis 2022d) and is the sum of cell E16 "Current transfers by corporations" plus E18" Current transfers by households" plus E20 "Capital transfers of corporations". The transaction **taxes and contributions from ROW** originates from Destatis (2022d) and is the sum of cell E23 "Current taxes on income, wealth etc. by the rest of the world" plus cell E27 "Actual social contrib. of the rest of the world". The **current account balance** originates from the national accounts Destatis (2022d). It is the result of cell E6 "Revenue" minus cell E23 "Expenditure".

2.2 Estimation of a balanced SAM

The resulting Proto-SAM shows imbalances in three accounts: the government's income is lower than the expenditure by 231.17 billion € (14.62 % of total expenditure), total savings are 262.82 billion € higher than investments (36.29 % of total savings) and the income to the ROW-account is lower than its expenditure by 31.65 billion € (1.92 % of total income). The cross-entropy method is applied to estimate a balanced SAM (Golan et al. 1994, Robinson et al. 2001). Thereby, the following macro totals of the national accounts are enforced on the estimation process:

1. import payments of 1385.31 billion € taken from cell J23 "Imports of goods and services" (Destatis 2022e),
2. value-added of 3035.17 billion € as published in Destatis (2022b), cell J6 "Gross value added",
3. private consumption of 1752.06 billion € taken from cell J8 "Household final consumption expenditure" (Destatis 2022e),
4. government consumption of 670.37 billion € (cell J11 "Government final consumption expenditure", Destatis 2022e),
5. exports of 1593.03 billion € (cell J22 "Exports of goods and services", Destatis 2022e).

Table 3 shows the resulting, estimated Macro-SAM and the enforced macro-totals.

Additionally, domestic supply and exports of C50 (shipping services) are fixed in the estimation process, as the original data suggests that this service commodity is exclusively exported and an unequal adjustment of these values would introduce a deviation from this.

The cross-entropy estimation leads to a redistribution of the residual values of individual accounts to bring about an equilibrium. Table 4 shows Micro-SAM cells with relative changes

(transitions subjected to changes that are above 25.00 % of their initial values). There are ten payments in Table 4: The payment from C06 “Petroleum and natural gas to mining and quarrying” increases by 61.77 %. The payment from C29 “Manufacture of motor vehicles, trailers and semi-trailers” to ROW increases by 30.35 %. Households pay 25.25 % and government pays 33.23 % more to C21 “Pharmaceutical products”. On the other hand, exports decline, specifically the exports of C06 “Petroleum and natural gas”, C14 “Clothing”, C15 “Leather and leather products”, C21 “Pharmaceutical products” and of C26 “Computer, electronic and optical products” are affected. Finally, the total savings decrease by 25.70 % to match the investment expenditure.

Table 3: Estimated 2018 Macro-SAM for Germany (billion €) and the enforced macro-totals (underlined)

	ACTIVITY	CMDTY	MRGN	FCTR	HH	GOV	ITAX	DTAX	S-I	WRLD	TOTAL
ACTIVITY		6231.48									6231.48
CMDTY	3199.75		536.20		1752.06[(2)]	670.37[(2)]			733.42	1593.03[(2)]	8484.83
MRGN		536.20									536.20
FCTR	3035.16[(1)]									237.57	3272.73
HH				2021.94		649.71				98.09	2769.73
GOV							946.80	467.22		14.63	1428.65
ITAX	-3.44	331.84		618.40							946.80
DTAX					467.22						467.22
S-I				510.11	441.41	61.50			15.30	-279.60	748.72
WRLD		1385.31 [(2)]		122.28	109.05	47.08					1663.72
TOTAL	6231.48	8484.83	536.20	3272.73	2769.73	1428.65	946.80	467.22	748.72	1663.72	

Totals enforced based on: [(1)] Destatis (2022b), [(2)] Destatis (2022e)

Table 4: Cells with relative changes of more than 25 % from their initial values (%)

	C06	C29	HH	GOV	ROW	Total
A05_09	61.77					
C06					-74.98	
C14					-62.04	
C15					-50.45	
C21			25.25	33.23	-50.16	
C26					-30.95	
S_I						-25.70
ROW		30.35				
Total						

Source: Author's compilation

Table 5 reports transactions, which change by more than 25% and exhibit absolute changes above 10 billion € at the same time, making these the most critical changes caused by the balancing algorithm. The respective absolute changes are reported in each cell. These are the increase of imports of C29 "Motor vehicles and parts", the increase of government consumption of C21 "Pharmaceutical products", the reduction of exports of C14 "Clothing", C21 "Pharmaceutical products" and C26 "Computer, electronic and optical products". Finally, this holds for the reduction of total savings, which shows the highest absolute change.

We believe that these changes would not considerably distort the overall quality of the data especially those related to the circular economy. If this SAM is to be used for a purpose for which these changes are crucial, users should consider revisiting them.

Table 5: Cells with large absolute and relative changes (billion €)

	C29	GOV	ROW	Total
C14			-12.99	
C21		12.73	-40.74	
C26			-37.70	
S_I				-253.70
ROW	38.43			
Total				

Source: Authors' compilation

3 Overview of the German economy as depicted in the 2018 SAM

This section describes the German economy in general considering the data depicted in the 2018 SAM. It highlights the top 4 contributions to the GDP by sector in addition to the waste and recycling sector. This allows bringing the waste and recycling sector into perspective. It also provides a summary of macroeconomic indicators, presents cost structures of main sector and income sources of the institutions. Moreover, it provides a brief overview over the trade accounts. The followings subsections list the first four largest shares of each transaction and as fifth transaction the waste and recycling sector for comparison. The waste and recycling activity A37_39 is an aggregate of the sectors sewage, waste disposal and recycling. The recycling commodity C38 is an aggregate of the commodities waste collection, treatment, disposal and recovery services. Further disaggregation of the waste and recycling activity and commodity is not possible, according to Destatis (2022f).

3.1 Sectoral contribution to GDP

The sectoral GDP values and shares in Germany are presented in Table 6. Agriculture accounts for the lowest share of GDP at factor cost with 0.92 %, manufacturing (without construction) accounts for 26.01 %, construction contributes 5.00 % and the service sector with the biggest contribution to the GDP accounts for 68.07 %. The waste and recycling activity A37_39 is an aggregate of the sectors sewage, waste disposal and recycling, all together are part of the aggregate manufacturing sector. The contribution of the waste and recycling activity to GDP is with 0.92 % (compare Table 11) and 28.00 billion € almost as high as the contribution of the agricultural sector.

Table 6: GDP contributions of aggregated sectors

Sector	billion Euro	%
Agriculture	28.06	0.92
Manufacturing	789.40	26.01
Construction	151.72	5.00
Service	2065.98	68.07
Total	3035.17	100.00

Source: Authors' compilation

3.2 Sources of household and government income

The household income sources are the columns in the SAM that pay transactions to the household row account, the shares of which in total household income is reported in Table 7. There are four income sources for the household in the SAM. The production factors (labor and capital) account for 73.00 % of total income to the household with labor being the largest contributor with 41.80 %. The remaining 27.00 % are transfers from the government and the rest of the world.

Table 7: Household income sources and their contributions

Rank	Description	%
1	Labor	41.80
2	Capital	31.20
3	Government	23.46
4	Rest of the world	3.54

Source: Authors' compilation

The government's 5 income sources, and their share are reported Table 8. The social contributions, direct tax, and taxes on products account for 99.22 % of the overall income of the government. The aggregate taxes paid by activities (production taxes) are reported as a negative number indicating that production subsidies are higher that production taxes in aggregate.

Table 8: Government income sources and their contributions

Rank	Description	%
1	Social contributions	43.29
2	Direct tax	32.70
3	Taxes on products	23.23
4	Rest of the world	1.02
5	Activity tax	-0.24

Source: Authors' compilation

3.3 Macroeconomic indicators

Selected macroeconomic indicators based on the SAM are reported in Table 9 and Table 10. The GDP at factor cost is the sum of all payments of the activities to the production factors with a value of 3035.16 billion Euro. The recurrent fiscal balance is the government savings/deficit with the positive value in 2018 indicating a surplus. The negative current account balance indicates a net capital outflow from Germany to the rest of the world represents the savings of the rest of the world. Private savings are the payments from the households to the savings and investment account. The figure indicates positive savings made by aggregate private households. The GDP at market prices is calculated as the sum of final consumption of households, government consumption, investment demand and net exports.

Table 9: Macroeconomic indicators

Indicators	Value (billion Euro)
GDP at factor cost	3035.16
Recurrent fiscal balance	61.50
Current account balance	-279.60
Private savings	441.41
Investment	733.42
Imports	1385.31
Exports	1593.03
GDP at market prices	3378.87

Source: Authors' compilation

The ratio of trade to GDP is calculated as the sum of exports plus imports divided by GDP at market prices, and shows that Germany is quite integrated with global markets. The fiscal balance to GDP is calculated as the government savings divided by the GDP at market prices. The current account balance is calculated as the savings of the rest of the world divided by the GDP at market prices. The private savings to investment is calculated as the household savings divided by the investment demand (Table 10).

Table 10: Macroeconomic ratios

Ratios	%
Trade to GDP	88.15
Fiscal balance to GDP	1.82
Current account balance to GDP	-8.27
Private savings-to-investment	60.19

Source: Authors' compilation

3.4 Sectoral GDP at factor costs and factor intensities

The sectoral share in GDP at factor cost is calculated as the share of labor and capital use by each activity divided by the total value added (capital and labor use at the national level) and the top 4 contributors are reported in the third column of Table 11. The highest contribution is from "Real estate and housing activities", which alone contributes by 10.23 % to the German GDP. "Sewage, waste disposal and recycling" is ranked 32nd out of 63 activities and contributes 0.92 % to the German GDP. The top three activities are the service activities and account for more than a fifth of the GDP at factor cost.

The labor/capital intensity within each sector is calculated as the share of labor/capital in the total production cost of the sector (column shares). As expected, "Public administration and defense with compulsory social security sector" is most labor intensive among the top largest four sectors with more than half of its cost structure devoted to labor while real estate and housing activities is the most capital-intensive sector among them (Table 11).

Table 11: Sectoral shares in GDP at factor cost and labor/capital intensities

		%		
Rank	**Description**	**GDP**	**Labor**	**Capital**
1	Real estate and housing activities	10.23	3.62	68.72
2	Public administration and defense with compulsory social security	5.96	50.45	12.60
3	Health care	5.37	47.81	20.75
4	Construction	5.00	25.40	18.68
32	Sewage, waste disposal and recycling	0.92	17.50	26.28

Source: Authors' compilation

3.5 Labor and capital input per sector

The sectoral labor share in total labor force in Germany is calculated as the payment of each sector to the labor factor relative to total labor income (Table 12). The sector with the highest labor input is "Public administration and defense with compulsory social security". The four sectors with the highest labor input account for a fifth of the overall employment in Germany. With respect to labor input ranking of sectors, "Sewage, waste disposal and recycling" is ranked 37th of 63 activities.

Table 12: Labor employed per sector as share in total labor force

Rank	**Description**	**%**
1	Public administration and defense with compulsory social security	8.15
2	Health care	6.40
3	Education	6.31
4	Wholesale trade (except of motor vehicles and motorcycles)	4.96
37	Sewage, waste disposal and recycling	0.63

Source: Authors' compilation

The sectoral capital share in total capital income in Germany is calculated as the payment of each sector to the capital factor relative to total capital income (Table 13). The sector with highest capital input in Germany is "Real estate and housing activities". The four activities with the highest capital share account for 38.65 % of the overall capital used in Germany. Among the 63 activities in the SAM, "Sewage, waste disposal and recycling" is ranked 25th based on its capital input use.

Table 13: Capital use per sector as share in total capital use

Rank	Description	%
1	Real estate and housing activities	23.43
2	Manufacture of motor vehicles, trailers and semi-trailers	5.59
3	Construction	5.11
4	Wholesale trade (except of motor vehicles and motorcycles)	4.52
25	Sewage, waste disposal and recycling	1.33

Source: Authors' compilation

3.6 Taxes, subsidies and margins

Total tax revenues are reported directly from the Marco-SAM. They include direct taxes on households, social insurance contributions, taxes and subsidies on production, and taxes on products. Direct tax revenues are shown in Table 14.

Table 14: Direct taxes on households and social insurance payments by labor

Description	Value (billion Euro)
Direct tax paid by households	467.22
Social insurance payments by labor	618.40

Source: Authors' compilation

Activity tax rates are calculated as percentage of the total cost of production (activities column shares). Ranking the sectors by their tax rates puts the "Financial services" on the top followed by real estate and housing, while the "Sewage, waste disposal and recycling" sector is not taxed (Table 15). The five first activities on the list account for 5.15 % of the overall activity tax collected. "Sewage, waste disposal and recycling" is not included in Table 15 because it is subsidized and therefore only listed in Table 16.

Table 15: Activity tax rates

Rank	Description	%
1	Financial services	2.36
2	Real estate and housing activities	1.86
3	Wholesale trade (except of motor vehicles and motorcycles)	0.43
4	Retail trade (except of motor vehicles and motorcycles)	0.26
5	Arts and culture, gambling	0.24

Source: Authors' compilation

Activity subsidy rates are calculated as percentage of the total cost of production (activities column shares). The value is derived through the division of the value of the subsidy by sector by the overall production cost of the sector. "Agriculture" receives the highest rate of subsidies and "sewage, waste disposal and recycling" is on place 13 of 24 (Table 16). "Manufacture of fabricated metal products", "Other transport equipment", "Electrical equipment" and "Domestic services" are not taxed or subsidized.

Table 16: Activity subsidy rates

Rank	Description	%
1	Agriculture	-11.85
2	Mining and quarrying	-10.18
3	Research and development	-3.45
4	Fishing	-3.11
13	Sewage, waste disposal and recycling	-0.58

Source: Authors' compilation

Rates of product taxes are calculated trough the columns share of commodities from the Micro-SAM. The highest tax rate is levied on "Tobacco products" while the "Waste collection, treatment, disposal and recovery services" commodity is ranked 56th of 85 commodities (Table 17).

Table 17: Product tax rates

Rank	Description	%
1	Tobacco products	57.19
2	Petroleum products	30.31
3	Beverages	15.51
4	Insurance and pension funding services	14.61
56	Waste collection, treatment, disposal and recovery services	1.09

Source: Authors' compilation

Trade and transport margins are calculated as column shares of commodities. The highest trade and transport margin is associated with "Clothing" while the "Waste collection, treatment, disposal and recovery services" sector is ranked 33rd of 85 commodities (Table 18).

Table 18: Trade and transport margins

Rank	Description	%
1	Clothing	37.63
2	Leather and leather products	34.62
3	Beverages	33.40
4	Furniture	30.65
33	Waste collection, treatment, disposal and recovery services	4.31

Source: Authors' compilation

3.7 Exports and imports of commodities

To rank the exported commodities based on their share in total exports, we calculated the rest of the word column shares excluding other payments from the rest of the world beside exports of commodities. “Motor vehicles and parts” are the most important export. The four biggest exports are all manufactured products and account for almost 47.54 % of total exports. Exports of “Waste collection, treatment, disposal and recovery” services are ranked 31st of 85 commodities (Table 19).

Table 19: Export shares

Rank	Description	%
1	Motor vehicles and parts	18.54
2	Machinery	14.50
3	Chemical products	8.39
4	Electrical equipment	6.11
31	Waste collection, treatment, disposal and recovery services	0.59

Source: Authors’ compilation

Export intensity is calculated as commodity export value divided by the commodity production value. The top 9 commodities with the highest export intensity are fully exported (i.e., export intensity = 100 %). These are: “Rubber products”, “Electrical equipment”, “Crude oil and natural gas”, “Leather and leather goods”, “Computer, electronic and optical products”, “Clothing”, “Pharmaceutical products”, “Shipping services”, and “Chemical products”. The top four commodities which are both exported and consumed domestically are shown in Table 20. The “Waste collection, treatment, disposal and recovery services” commodity is ranked 37th of 85 commodities with 21.73 % export intensity.

Table 20: Export intensity of commodities with export intensity of below 100 %

Rank	Description	%
1	Textiles	99.23
2	Other goods	95.56
3	Other vehicles	95.24
4	Machinery	92.73
37	Waste collection, treatment, disposal and recovery services	21.73

Source: Authors’ compilation

Row shares of the rest of the world account excluding transactions other than imports are used to derive the most important imports. The commodity with the highest share in total commodity imports is "Motor vehicles and parts" while "Waste collection, treatment, disposal and recovery services" commodity is ranked 32nd of 85 commodities. The top four imported commodities are industrial commodities and together account for 23.53 % of total German imports in 2018 (Table 21). Thereby, the top 3 are the same as for the export shares (compare Table 19).

Table 21: Import shares

Rank	Description	%
1	Motor vehicles and parts	11.91
2	Machinery	8.29
3	Chemical products	7.83
4	Computer, electronic and optical products	7.41
32	Waste collection, treatment, disposal and recovery services	0.70

Source: Authors' compilation

The import penetration ratio, is calculated as the share of each commodity import in the total domestic demand of that commodity from the Micro-SAM. The total domestic demand of each commodity in the SAM is calculated by deducting exports and margins from the total income of each commodity. Ores are exclusively imported, while the "Waste collection, treatment, disposal and recovery services" commodity is ranked 36th of 85 commodities with a penetration rate of 22.07 % (Table 22).

Table 22: Import penetration ratio

Rank	Description	%
1	Ores	100.00
2	Hard coal	97.88
3	Shipping services	97.77
4	Chemical products	95.73
36	Waste collection, treatment, disposal and recovery services	22.07

Source: Authors' compilation

3.8 Household and government consumption of commodities

The household commodity consumption shares are calculated as the column shares of the household consumption vector. According to these rates, "Real estate and housing services" make the highest expenditure share while "Waste collection, treatment, disposal and recovery services" only account for 0.37 % of total household expenditure, which ranks it 45th of 85 commodities. The top four commodities together account for 34.58 % of the total household commodity demand (Table 23). Households demand 70 out of the 85 commodities included in the SAM.

Table 23: Commodity shares in total household consumption

Rank	Description	%
1	Real estate and housing services	16.52
2	Foodstuffs and animal feed	8.34
3	Accommodation and food services	5.36
4	Motor vehicles and parts	4.37
45	Waste collection, treatment, disposal and recovery services	0.37

Source: Authors' compilation

The share of commodities in the government consumption is calculated as the column shares of the government consumption vector in the Micro-SAM. As expected, the commodity with the highest share is "Public administration and defense services", followed by health and then education. "Waste collection, treatment, disposal and recovery services" accounts for only 0.16 % of government expenditure (Table 24). The government demands 25 out of the 85 commodities.

Table 24: Commodity shares in total government consumption

Rank	Description	%
1	Public administration and defense services	28.01
2	Health care services	24.85
3	Educational services	17.85
4	Residential care and social work services	9.59
13	Waste collection, treatment, disposal and recovery services	0.16

Source: Authors' compilation

3.9 Waste and recycling sector

The waste and recycling sector is an aggregate of the wastewater and waste disposal, recovery and recycling sectors. The income of the waste and recycling activity is calculated through the row share of the activity. Thereby "Waste collection, treatment, disposal and recovery services" contributes more than two thirds to the income of the waste and recycling activity (Table 25).

Table 25: Top five income sources of the waste and recycling activity as shares in total income

Rank	Description	%
1	Waste collection, treatment, disposal and recovery services	66.90
2	Sewage disposal services	24.76
3	Pollution and other disposal services disposal	1.67
4	Water, water supply services	1.25
5	Civil engineering	1.24

Source: Authors' compilation

The cost of production of the waste and recycling activity is calculated through the column shares of the activity account. The highest share in the cost of production occurs for capital, which accounts for more than a quarter of total costs. The total payment to factors constitutes 44.78 % of total cost, while 55.22 % of the cost is intermediate input demand (Table 26).

Table 26: Production cost shares of the waste and recycling activity

Rank	Description	%
1	Capital	26.28
2	Waste collection, treatment, disposal and recovery services	19.62
3	Labor	17.50
4	Architectural, engineering, and technical, physical surveying services	5.82
5	Preconstruction, construction installation and other finishing work	3.87

Source: Authors' compilation

The shares of demand sources for the recycling commodity are calculated through the row shares of the commodity account. The highest demand for the waste and recycling commodity arises as intermediate input into the "Sewage, waste disposal and recycling" activity, followed by exports and households consumption (Table 27).

Table 27: Top five accounts demanding the waste and recycling commodity

Rank	Description	%
1	Sewage, waste disposal and recycling	22.38
2	Rest of the world	16.78
3	Household	11.40
4	Rubber and plastic products	7.75
5	Manufacture of basic metals	7.69

Source: Authors' compilation

The supply of the waste and recycling commodity comes from different accounts in the SAM. The shares of the accounts supplying the commodity are calculated through the column shares of the commodity account. More than three quarters of the supply are domestic sources (Table 28).

Table 28: Input shares of the waste and recycling commodity

Rank	Description	%
1	Sewage, waste disposal and recycling	76.30
2	Rest of the world	17.41
3	Transport margins	4.31
4	Taxes on products	1.09
5	Electricity, gas and water supply	0.75

Source: Authors' compilation

4 Final remarks

The 2018 SAM for Germany, documented in this report comprises of 160 accounts including 63 activities and 85 commodities. In addition, margins, labor, capital, household, government, social contributions, taxes on products, activity tax, direct tax, stock changes, savings-and-investment and the rest-of-the-world are all represented in the SAM by a single account for each.

The SAM is based on the 2018 Input-Output table of the year 2018, by Federal Statistical Office of Germany (Destatis). For the purpose of our study, we did not need to invest in disaggregating households to sub-groups and did not single out enterprises. Such disaggregation would allow looking at distributional effects of different policies and changes.

Future improvement in the data with respect to the circular economy could be a further disaggregation of the waste and recycling sector, which was not possible within the timeframe of this research. The disaggregation in this respect would be to split the waste and recycling activity into its sub-components including “Sewage”, “Waste disposal” and “Recycling”.

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Appendix: Short names and English description of the Micro-SAM accounts

Short name	Description
A01	Agriculture
A02	Forestry
A03	Fishery
A05_09	Mining and quarrying
A10_12	Manufacture of food products, beverages and tobacco
A13_15	Textiles, clothing, leather goods & footwear
A16	Manufacture of wood and of products of wood and cork, except furniture
A17	Manufacture of paper and paper products
A18	Printers, reproduction of sound, images, data Audio, video and data media
A19	Coke and refined petroleum products
A20	Manufacture of chemicals and chemical products
A21	Pharmaceutical products
A22	Rubber and plastic products
A23	Glassware, ceramics, stone and earth products
A24	Manufacture of basic metals and fabricated metal products
A25	Manufacture of fabricated metal products
A26	Computer, electronic and optical products
A27	Electrical equipment
A28	Mechanical engineering
A29	Manufacture of motor vehicles, trailers and semi-trailers
A30	Other transport equipment
A31_32	Furniture and miscellaneous articles
A33	Repair and installation of machinery and equipment
A35	Power supply
A36	Water supply
A37_39	Sewage, waste disposal and recycling
A41_43	Construction
A45	Motor trade and repair of motor vehicles and motorcycles
A46	Wholesale trade (excl. trade with motor vehicles)
A47	Retail trade (except of motor vehicles and motorcycles)
A49	Land transport and transport via pipelines
A50	Shipping
A51	Aviation
A52	Warehousing, other transport service providers
A53	Postal, courier and express services
A55_56	Hospitality
A58	Publishing
A59_60	Audiovisual and broadcasting

Short name	Description
A61	Telecommunications
A62_63	IT and information service providers
A64	Financial services
A65	Insurance and pension funds
A66	Activities auxiliary to finance and insurance Activities
A68	Real estate and housing
A69_70	Legal and tax consultancy, management consultancy
A71	Architectural and engineering activities and technical testing and analysis
A72	Research and development
A73	Advertising and market research
A74_75	Professional, scientific and technical services n.e.c., veterinary activities
A77	Renting of movable property
A78	Placement and hiring out of workers
A79	Travel agencies and tour operators
A80_82	Business services n.e.c.
A84	Public administration and defense, compulsory social security
A85	Education and training
A86	Health care
A87_88	Nursing homes and social work
A90_92	Arts and culture, gambling
A93	Sports, entertainment and recreation
A94	Interest groups, religious associations
A95	Rep. of data processing equipment and consumer goods
A96	Other predominantly personal service providers
A97_98	Domestic services
C01	Agricultural products, hunting and services
C02	Forestry products and services
C03	Fish, fishery and aquaculture products
C5_1	Hard coal
C5_2	Lignite
C06	Crude oil and natural gas
C07	Ores
C08_09	Crude and manufactured minerals, other mining products and services
C10	Foodstuffs and animal feed
C11	Beverages
C12	Tobacco products
C13	Textiles
C14	Clothing
C15	Leather and leather goods
C16	Wood, wood products, wickerwork and cork products (excluding furniture)
C17_1	Wood and pulp, paper, cardboard and paperboard products

Short name	Description
C17_2	Paper, cardboard and paperboard goods
C18	Printing services, recorded sound, image and data media
C19_1	Coke oven products
C19_2	Petroleum products
C20	Chemical products
C21	Pharmaceutical products
C22_1	Rubber products
C22_2	Plastic products
C23_1	Glass and glassware
C23_2_23_9	Ceramics, worked stone and earth
C24_1_24_3	Pig iron, steel, products of first processing of iron and steel
C24_4	Non-ferrous metals and semi-finished products thereof
C24_5	Foundry products
C25	Metal products
C26	Computer, electronic and optical products
C27	Electrical equipment
C28	Machinery
C29	Motor vehicles and parts
C30	Other vehicles
C31	Furniture
C32	Other goods
C33	Repair, maintenance and installation of machinery and equipment
C35_1_C35_3	Electricity, heating and cooling services
C35_2	Industrial gases, gas supply services
C36	Water, water supply services
C37	Sewage disposal services
C38	Waste collection, treatment, disposal and recovery services
C39	Environmental and other waste disposal services Disposal
C41	Building construction
C42	Civil engineering
C43	Preconstruction, construction installation and other finishing works
C45	Trade services of motor vehicles, maintenance and repair of motor vehicles
C46	Wholesale trade services, except of motor vehicles and motorcycles
C47	Retail trade services, except of motor vehicles and motorcycles
C49	Land transport and pipeline transport services
C50	Shipping services
C51	Aviation services
C52	Warehousing services, other transport services
C53	Postal, courier and express services
C55_56	Accommodation and food services
C58	Publishing services

Short name	Description
C59_60	Services of audiovisual. Media, music publishing and radio and television broadcasting services
C61	Telecommunication services
C62_63	IT and information services
C64	Financial services
C65	Insurance and pension funding services
C66	Services auxiliary to financial and insurance services
C68	Real estate and housing services
C69_70	Legal, tax and management consulting services
C71	Architectural, engineering and technical, physical surveying services
C72	Research and development services
C73	Advertising and market research services
C74	Other professional, scientific and technical services
C75	Veterinary services
C77	Renting services of movable property
C78	Labor recruitment and leasing services
C79	Travel agency, tour operator and other services Reservations
C80_82	Security guard services and other business services n.e.c.
C84_1_84_2	Public administration and defense services
C84_3	Social security services
C85	Educational and training services
C86	Health care services
C87_88	Residential care and social work services
C90_92	Art, culture and gambling services
C93	Sports, entertainment and recreation services
C94	Services of interest groups, ecclesiastical and other associations
C95	Repair of computer equipment and personal and household goods
C96	Other predominantly personal services
C97_98	Goods and services of private households o.o.
MARGINS	Transport costs
LAB	Labor
CAP	Capital
HH	Households
GOV	Government
TAXOP	Taxes on products
ATAX	Activity tax
DIRTAX	Direct taxes
SSC	Social contributions
SCH	Changes in inventories
S_INV	Savings and investments
ROW	Rest of the world
Total	Sum of all values