Transboundary movements of used and waste electronic and electrical equipment

Estimates from the European Union using trade statistics

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Sustainable Cycles Programme

step
solving the e-waste problem

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DISCLAIMER

Summary

European Union (EU-28) exports of second-hand, or waste refrigerators, freezers, laptops, desktop computers, televisions and monitors and flat panel displays were analyzed using trade statistics from the EU COMEXT database. Based on the findings of this analysis, the amount of exported of used electronic and electric equipment (EEE) and/or the waste thereof (e-waste) from the investigated products doubled from 5 kt in 2008 to 10 kt in 2013. The exports were mostly comprised of desktops, followed by refrigerators and flat panel displays.

The methodology was based on price discrimination of average price of the commodity flows. It can only trace whole units–not scrapped products. The analyzed data contained many flawed records, and due to the level of aggregation, it reflected a mix of prices. Consequently, the average prices is mainly determined by the new units in the mix; there would have to be an enormous quantity of low price exports to pull the average price down to what would be considered a reasonable price for a used good. Besides this, intentionally incorrectly reported data of e-waste, such as illegal exports, are not covered by this research, either. Therefore, the total quantity of exports is clearly an underestimate of the true total.

Despite this, the destinations from the analysis probably reflect the actual trading routes of used EEE or e-waste. As a general trend, the trade of all appliances increased from to 2008 to 2013. The fastest growth was observed in exports to Northern Africa and Western Africa, Southern Asia and Central Asia. However, the growth was not there for shipments towards all regions of the world; to some regions, declining or stable trends were observed. Generally, the commodities are merely exported from the EU-28 to countries of lower income in non-EU Europe, Asia and Northern and Western Africa. A general trend was found that the low-value items, such as refrigerators, were exported to the poorest countries, and the higher-value items, such as laptops, were exported to the countries with higher purchasing powers. In geographic terms, the following trends were found: refrigerators and freezers were exported to Western Africa, laptops, desktops and flat panel displays were exported to Northern Africa, mobile phones were exported to Eastern Asia. CRTs were mostly exported to Southeast Asia, which may imply that there is still demand for CRT glass in closed-loop recycling in this region. In absolute terms, most of the exports were to regions that are either close to Europe (such as non-EU European countries, Northern or Western Africa) or to regions that have well established trading connections (such as to Southeast Asia). As expected, there were hardly any exports to Oceania, North America or Southern America.

The imports documented can have a large impact on local economies. According to this dataset, it can equal up to 10 to 15 per cent of the regional market. For individual countries, especially countries with few inhabitants or those with small economies, the impact can be even larger–up to 40 per cent of the total e-waste generated from that particular appliance. Due to the nature of the method used, exports to small countries or small economies are detected easier than exports to large economies. Therefore, the impact of the exports is expected to be significant in the importing countries, even if this does not show up in this data.

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1 INTRODUCTION

E-waste, or waste electrical and electronic equipment, is an emerging and fast-growing waste stream with complex characteristics. The growing amount of e-waste has posed a significant challenge to waste management in both developed and developing countries. Rapid increase of sales, innovations and shortening product lifespans are among the factors contributing to the growing amount of e-waste.

In 2014, the global population discarded an estimated 41.8 million metric tonnes (megatons – Mt) of waste electrical and electronic products, and the volume of e-waste is expected to increase by 21 per cent to 50 million Mt in 2018.

The United Nations University (UNU) recently published that most of the e-waste generated in 2014 occurred in Asia [1]: 16 Mt. This represents 3.7 kg per inhabitant. This was followed by the Americas, which generated 11.7 Mt (7.9 Mt for North America, 1.1 Mt for Central America and 2.7 Mt for South America), which represents 12.2 kg/inh on average. The highest per capita e-waste quantity (15.6 kg/inh.) was generated in Europe. The whole region (including Russia) generated 11.6 Mt. The lowest quantity of e-waste was generated in Oceania, and was 0.6 Mt. However, the per capita amount was nearly as high as Europe's (15.2 kg/inh.). The lowest amount of e-waste generated per capita was in Africa, where only 1.7 kg/inh. was generated in 2014. The whole continent generated 1.9 Mt of e-waste in 2014.

E-waste contains of a large variety of products, which can be grouped into six main categories. These are: temperature exchange equipment (cooling and freezing equipment), screens, lamps, large equipment, small equipment and small IT equipment. These six main groups can be further categorised into 54 unique UNU-KEYS [2], where each UNU-KEY is characterised by homogeneous composition, environmental relevancy, average weight and lifespan. Discarded appliances have a varying end-of-life (EoL) value due to potential recoverable recyclables, but they also have and toxic constituents that need to be disposed of carefully. Over the past two decades, policymakers, producers and recyclers recognized the need to recycle e-waste, and therefore, various countries have created specialised take-back and treatment systems to collect e-waste from final owners and process it in professional treatment facilities. Despite these efforts, there is a large portion of e-waste that is not being collected and treated in an environmentally sound manner. Only 6.5 Mt of the 41.8 Mt of e-waste was documented and recycled with the highest standards [1]; the fate of the majority of the e-waste is still unknown.

Some of the world's e-waste is shipped great distances to developing countries, where crude and inefficient techniques are often used to extract materials and components. This might violate the Basel Convention. These crude techniques pose dangers to poorly protected workers, the neighbourhood and the local natural environment. Global trading of electronics and substandard recycling in developing countries has led to environmental catastrophes in places like Guiyu, China and Agbogbloshie, Ghana, to name just two prominent examples. It is expected that managing used electronics and e-waste is one of the most important and challenging issues in the world.

Although there are previous studies on transboundary e-waste flows [3, 4], there are no accurate and comparable figures regarding their routes and volumes in the absence of internationally agreed upon methodology for generating the data and robust data sets. The transboundary movement of e-waste (mostly from developed to developing countries) is not easy to monitor, as it is not comprehensively

recorded and when it is, those recording often use different methodologies. The most significant international guidelines that addresses the management and transboundary movement of e-waste are the technical guidelines on re-use, recycling and transboundary movement currently being devised under the auspices of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal [5]. The Basel Convention was adopted in 1989 and entered into force in May of 1992, with later addendums in 2006 (Nairobi Declaration) and 2011 (Cartagena Decisions). The Basel Convention was developed to address waste streams, in general. In 2006, the EU transposed the Basel Convention and the OECD Council Decision into European regulation with the European Waste Shipment Regulation (WSR). The WSR implements the international obligations of the two regulations and includes the internationally agreed upon objective that wastes shall be disposed of in an environmentally sound manner.

The Basel Convention classifies hazardous waste in terms of the substances in the waste materials. Therefore, the Convention does not list, for example, computers as hazardous and keyboards as non-hazardous. Instead, it classifies wastes depending on their chemical properties. This implies that the Convention does not have a specific rule for all forms of used and EoL electronics [5].

The national reporting data by the Parties to the Basel Convention mandated under Article 13 provides some information to analyze flows and amounts of transboundary movement of e-waste [4][6], but it is insufficient for a comprehensive analysis for the following reasons:[1]

- **Incomplete reporting**: Many Parties do not submit a national report, with less than 50 per cent submitting their reports for 2009) [6];
- **Ambiguous definitions**: Interpretation of definitions is different among the Parties, which results in irregularities that impede aggregating and analyzing data;
- **Incorrect categorization**: A type or category of hazardous waste is different among the Parties despite the Annex I, Annex VIII and Annex IX of the Basel Convention which provide the categories of wastes to be controlled, the list of hazardous wastes to be controlled and the list of non-hazardous wastes, respectively;
- **Discrepancies in reporting**: The amount of transboundary movement of hazardous wastes in the national reports may be not exact, because the amounts described in a notification and a movement document are usually different (this is because the amount described in a notification is a maximum amount of expected transboundary movement of hazardous wastes); and
- **Data inaccuracies**: Often, the same transboundary shipment is reported to have different amounts of a hazardous waste described by an importing country and by an exporting country.

Next to these previously mentioned limitations of using the registrations of the Basel Convention, only legal shipments of hazardous e-waste are documented here. Trade in second-hand EEE and illegal shipments is not captured by the reporting of the Basel Convention.

It is also difficult to reach accurate an estimate of the transboundary flows due to the illicit nature of the illegal shipments. Existing estimates on such quantities are obtained either from extrapolations from customs data on export violations, or by identifying the data gap from national material flow analysis.

[1] Text in the bullet points is obtained from an forthcoming publication in 2016 of the United Nations University named:

Usually, the calculated results from such methods usually have a high level of uncertainty, due to absence of complete datasets on all e-waste flows and fluctuation caused by market and social conditions.

When looking into the trade data of EEE, it is difficult to directly estimate the quantity of transboundary shipment of e-waste. There are multiple reasons associated with this issue:

- First, there is no special waste code associated with e-waste trading. Shipment of new electronic products, secondhand equipment and e-waste are usually registered under the same goods codes. It is infeasible to easily distinguish the conditions of the products (new, secondhand or obsolete) by looking into the international trade statistics.
- In the meantime, e-waste trade can also be registered or reported under the general waste codes. In this way, e-waste is mixed with other types of solid waste, such as mix-metal scrap, plastic waste or even municipal waste. It is also difficult to distinguish the quantity of e-waste trading from other waste types.
- Furthermore, due to the illicit nature of e-waste trading, such shipments are usually not properly reported or registered with customs. Rather, it is likely that traders report false information to the customs officials to avoid further checking.
- The cost of custom checking for shipment violations is very high; it demands a lot of effort in the ports to obtain representative data on the size of the illegal trading, by sampling the containers and the documented paperwork.

Therefore, many uncertainties exist when analyzing e-waste related trade data, mainly due to a lack of a proper registration in custom registries for e-waste. Considering these drawbacks of applying trade data to identify the used EEE or e-waste trade flows, this report aims to discriminate used EEE and e-waste from new commodities with trade data using price information from the trade. The original methodology for this process was developed by MIT/NCER and was applied for the United States only [3]. In this report, the method is slightly simplified by using price thresholds, instead of Gauss curve fitting. The impact of the simplification is expected to be small. The simplification allowed investigators to scale up the methodology for an efficient handling of more appliances, use a longer time series and focus in on each of the 28 EU Member States. This will potentially provide insights for the size and value of the e-waste flows that have been registered under the goods codes. It also helps to characterize the geographic distribution of e-waste exports. The data will be also compared to the e-waste arising data per appliance of the receiving countries that was available from UNU First e-waste monitor [1] to study the impact on local markets.

In this report, the commodity export data from the EU-28 was used as a case study. It covers the time period between 2008 and 2013. The export data from the EU-28 were analyzed for: laptops (UNU-Key 0303), desktops (UNU-Key 0302), mobile phones (UNU-Key 0306), CRT panel displays (UNU-Keys 0308 and 0407) and flat panel displays (UNU-Keys 0309 and 0408) and refrigerators and freezers (UNU-Keys 0108 and 0109). It is noted that the transport of e-waste within EU Member States is out of the scope for this study, and only the export out of the EU region was considered.

It is important to emphasize that the practice in this study only looks into the e-waste trade that is potentially included in the commodity trade data. The results do not reflect the full scale of the transboundary e-waste flows, as usually such shipment is not properly registered or fully reported under

the commodity codes such as scrap codes. However, checking the portion of the shipment through the commodity trade data can provide a general picture of the global e-waste trading landscape.

2 METHODOLOGY

2.1 GENERAL METHODOLOGY

The second-hand and new appliances are differentiated using price information in the trade statistics. This method has been developed by MIT/NCER [3], and as argued in that report, the methodology works best with detailed data, preferably on the shipment level. However, such data is not available in practice on a large scale. The available datasets are aggregated data. The analysed data reflect a mix of prices of individual transports, since none of the prices are negative or zero, the average prices will tend to be pulled higher by the new units in the mix; there would have to be an enormous quantity of low priced exports to pull the average price down to what would be considered a reasonable price for a used good.

Therefore, the data with the highest level of detail have been downloaded from the COMEXT database from Eurostat. The extractions comprised of monthly export data between a country in the EU (28 EU Member States), and another country between the years 2008 to 2013. The full list of commodity codes in the Combined Nomenclature (CN) classification is listed in ANNEX 1. For instance: a typical record consisted of: January 2012, exports from Czech Republic to Ukraine, for code 8471 3000 (the CN code of laptops) are 4000 units, 9000 kg, with a value of 500.000 euro. The initial dataset contained about 780,000 records. Unfortunately, the trade data contains some mistakes on a record at this level of detail. A typical mistake could be that the average weight per item can be completely unrealistic, for instance, 10 kg per item for a mobile phone, or 2 kg for a refrigerator. Those erroneous entries can affect the analysis of the price of the trade, negatively impact the analysis and need to be excluded from the analysis. Therefore, each record is checked for its average weight. If the average weight of the record falls within the boundaries of being realistic for the appliance, it is selected for the next steps of the analysis. The boundaries are shown in the Annex 1. From the 780,000 initial records, only 230,000 remained after this step and served as the basis of the following calculations. As a next step, a price threshold is determined using a price threshold. The methodology is a simplified one as developed by MIT/NCER [3]. It assumes that most of the EEE trade pertains to new equipment, with a higher price than trade of second-hand equipment. In the overview given in Figure 1, it is clearly seen that the price per unit grows moderately to EUR 50 per item, where it stabilizes to around EUR 75 per item. After EUR 75 per item, the exports grow much faster. The threshold is set at the plateau–in this case, around EUR 75 per item. For each appliance and for each year, a boundary was determined. Those boundaries were checked on consistency in time series and adjusted when needed. After this step, 13,000 records were below the boundaries and were marked as being used or waste EEE.

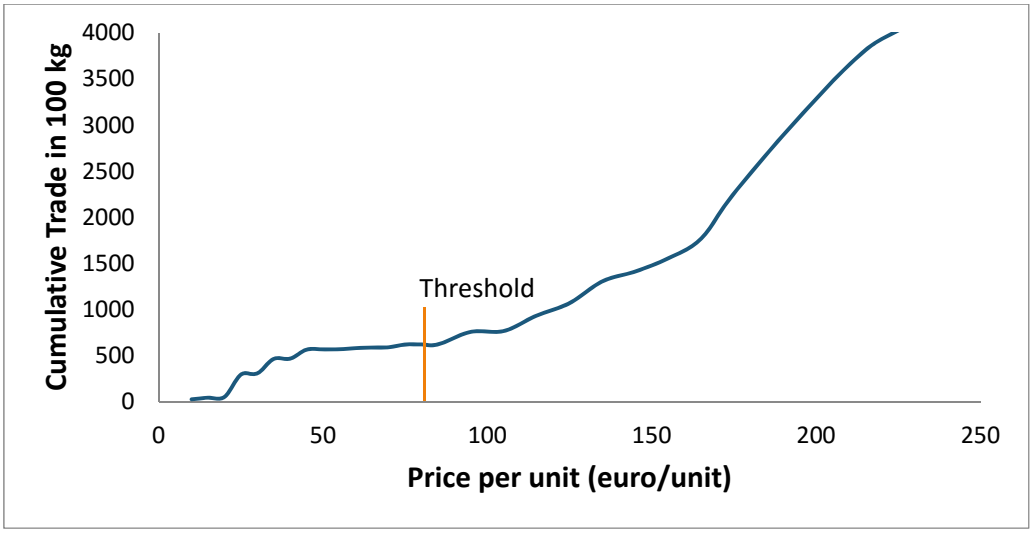


Figure 1: Overview of the price per unit for exports of laptops, year 2010, laptops (UNU-KEY 0303)

The identified trade routes of second-hand equipment were not extrapolated. Finally, the CN codes have been linked to UNU-KEYS, a UN recognised classification for EEE [2]. The links between the CN codes and the UNU-KEYS are provided in ANNEX 1.

2.2 LIMITATIONS OF THE ANALYSIS

As mentioned before, not all records in the raw dataset were of good quality. Often, average weight was incorrect. This clearly limits the analysis, as mistakes in the physical units can lead to dubious prices, which could lead to incorrect conclusions. Therefore, a large number of records were discarded, and those discarded data points could have contained valuable information. Additionally, when trade between two relatively large countries is analysed, in which 30 per cent of the trade was second-hand, the remaining 70 per cent was new equipment, trade of second hand equipment is undetectable, since the relatively high price of the new equipment dominates the data analysed. Therefore, the volumes of trade that have been detected are significant underestimates of the real totals. However, the routes of the trades are considered to be representative.

Next to the previous mentioned limitations that specifically apply for the method. General limitations of using trade statistics also apply. These include: that misreported shipments are not captured (eg. shipments of e-waste being classified as metal scrap); shipments where the destination country from Europe is a trading hub, such as Hong Kong or Dubai are not representative. In practive the second hand EEE or e-waste is then further shipped to other countries.

3 RESULTS – EXPORTER PERSPECTIVE

3.1 GENERAL TRENDS FOR EXPORTS FROM EU-28

Based on the findings from the analysis, the exports of used EEE and/or e-waste from EU-28 of the investigated products doubled from 5kt in 2008 to 10kt in 2013 in the EU-28 (Figure 2). The exports were mostly comprised of desktops, followed by of refrigerators and flat panel displays. The exports peaked in 2012, caused by a peak in desktop exports. The total value also grew from 30 million EUR in 2008 to just over 100 million EUR in 2013 (Figure 3). The main growth in value was caused by mobile phone (0306) and flat panel display (0309 and 0408) exports.

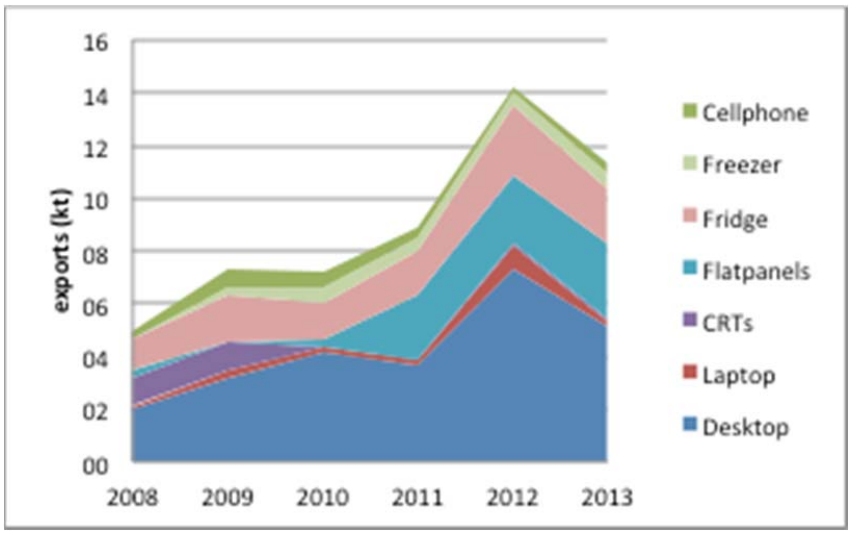


Figure 2: Exports from EU-28 Member States (in kt)

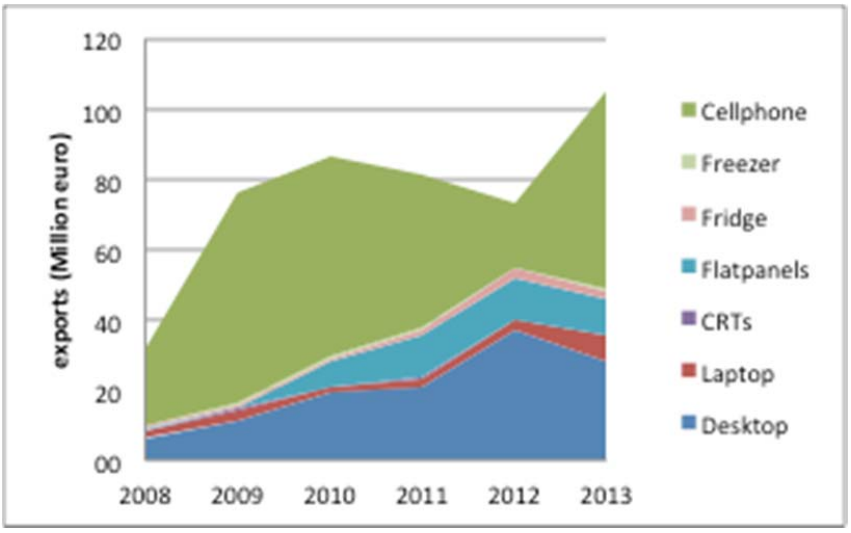


Figure 3: Exports from EU-28 Member States (in millions of euros)

As expected total e-waste generated from the investigated goods is significantly higher than the exports of used EEE from the EU (Table 1). From here, one would tentatively consider the data as an underestimate. This is further acknowledged, when looking into the following main mass flow calculations within the EU-28, which suggests that many exports of whole equipment are not reported or detected. This can be due to reporting with other codes, or due to flows of new equipment that bear a higher value.

In 2012, 1.5 Mt e-waste of screens (UNU-Keys 0303, 0308, 0309, 0407 and 0408) were generated in the EU-28 [7]. Of this, 0.80 Mt was collected, recycled and documented according to the WEEE Directive. Further, it is estimated that 0.09 Mt was discarded in the waste bin, 0.10 Mt was recycled with other recyclables, and 0.09 Mt was exported for reuse. This leaves a gap of 0.50 Mt in 2012 [8]. In this analysis, only 3 kt of screens (that is the 13 kt cumulative for 2008-2013 for CRT screens and Flat Panel displays in Table 1) were identified. For cooling and freezing equipment, a similar pattern was found; approximately 1.4 Mt of e-waste was generated. This is an aggregate mainly comprised of refrigerators, freezers and air conditioners. In the EU, 0.7 Mt were collected, recycled and documented according to the WEEE Directive, 0.2 Mt were recycled into other waste streams, and 0.03 Mt were exported for reuse [8].

	UNU-Key	E-waste generated (kt) [7]	Detected second-hand exports in this study (kt)
Desktops	0302	1,300	25
Laptops	0303	550	2
Mobile Phones	0306	120	3
CRT panel displays	0308 and 0407	2,700	3
Flat panel displays	0309 and 0408	900	10
Fridges	0108	4,600	11
Freezers	0109	1,100	3
Total		15,000	55

Table 1: Cumulative e-waste generated and cumulative detected exports for 2008 to 2013

The reason that the exports of the second-hand equipment are very small compared to the other flows can be understood with insight from the methodology and behind the calculations, as reviewed before. Illegal flows, and (un)intentional misreporting will not be captured by this method. Thus, the trades represent a minimum of the total transboundary wastes of used EEE or e-wastes.

4 REGIONAL IMPACTS OF EXPORTS

When the average purchasing power of the countries where the second hand commodities were imported are analyzed, a general trend was found that on average the low-value items were exported to the poorest countries, and on average the high-valued items to the countries with a higher purchasing power (see Figure 4). It was found that mobile phones had the highest value, near 90 euro/kg. This was followed by laptops, desktops and flat panels had a value of approximately 4 to 8 euro/kg. The lowest value was found for CRT screens, refrigerators and freezers, which all had a value lower than 1 euro/kg.

The exports of refrigerators and freezers were on average exported to "low to middle income" countries. Exports of IT-related equipment were, on average, exported to the upper middle-income countries. Exports of mobile phones were mostly to high-income non-OECD countries. Laptops, desktops and flat panel display panes were mostly exported to Northern Africa, mobile phones to Asia, refrigerators and freezers to Western Africa and CRT Screens to Asia. An overview of the destination of the exports is given in ANNEX 2.

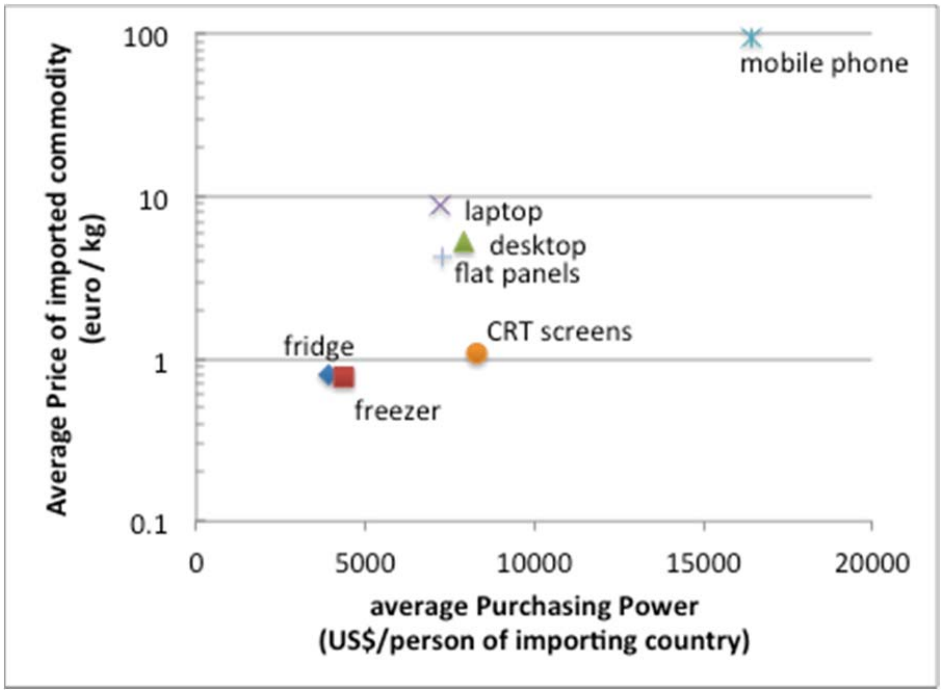


Figure 4: Overview of the average price of the used commodity and the average purchasing power of the receiving country after analysis of all used EEE exports.

In the following sections, the characteristics and impacts in the receiving region is described and analyzed.

4.1 EXPORTS TO NON-EU EASTERN EUROPE

BELARUS, REPUBLIC OF MOLDOVA, RUSSIAN FEDERATION, UKRAINE

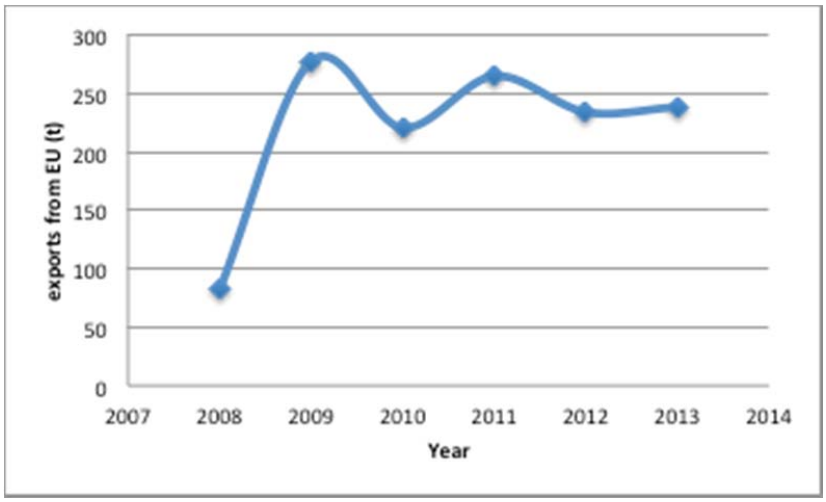
Overview

Roughly 0.9 kt of the researched flows go to non-EU Eastern Europe every year. This is an equivalent of EUR 12 million, most of which is attributed to mobile phones. The exports grew considerably between 2008 and 2009, but they stabilized afterwards. This was due to zero export of freezers (UNU-KEY 0109) to that region in 2008. In the Eastern non-EU countries, the imported goods typically represent less than 1 per cent of the e-waste generated of that region. Its impact on the total region is very modest, typically less than 2 per cent on the e-waste of the analyzed products. For Moldova however, a significant impact was found. Imports of second-hand laptops into Moldova currently represent 20 per cent of the e-waste generated of the country, and freezers and refridgerators both represent up to 34 per cent of the e-waste-generated. Most imports in terms of value go to Ukraine, and most imports in terms of weight go to Moldova and Ukraine.

Main data table

Non-EU Eastern Europe	Imports per year (tonnes)	Value (millions of Euros)	Share of imported products compared to waste domestically generated of the same appliances
Laptops and desktops	41	0.5	0%
Refrigerators and freezers	101	0.1	0%
CRT screens	1	0.0	0%
Flat panel screens	60	0.6	0%
Mobile phones	57	5.2	2%

Time series of exports to non-EU Eastern Europe



4.2 EXPORTS TO NON-EU SOUTHERN EUROPE

Albania, Bosnia and Herzegovina, Montenegro, Serbia, The former Yugoslav Republic of Macedonia

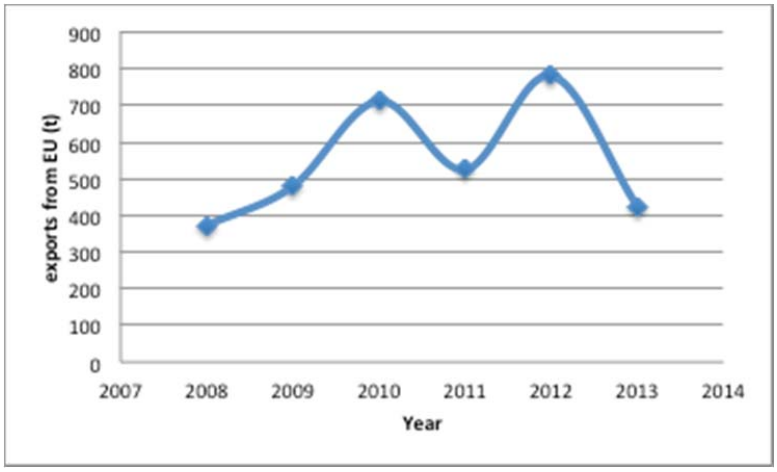
Overview

Roughly 0.9 kt of the researched flows go to non-EU Eastern and Southern Europe every year. This is the equivalent of EUR 12 million (most of which is attributed to mobile phones, laptops, desktops and flat panel displays). The trade seems to increase from 2008 to 2010, and it peaked in 2012. However, trade slowed in 2011 and in 2013, where it returned to 2008 levels. The impact of those exports is very large into non-EU Southern Europe; it can make up to 15 per cent of the e-waste generated market in that region for desktops, laptops and flat panel screens. Most imports in terms of weight go to Albania, closely followed by Bosnia Herzegovina. Most of those originate from Germany. In terms of value, most exports go to Albania and Serbia. For Serbia, only amounts of used mobile phones (UNU-KEY 0306) were detected.

Main data table

Non-EU Southern Europe	Imports per year (tonnes)	Value (Millions of Euros)	Share of imported products compared to waste domestically generated of the same appliances
Laptops and desktops	247	1.4	14%
Refrigerators and freezers	130	0.2	2%
CRT screens	4	0.0	4%
Flat panel screens	226	1.2	15%
Mobile phones	24	2.8	5%

Time series of exports to non EU Southern Europe



4.3 EXPORTS TO EASTERN AFRICA

Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mayotte, Mozambique, Réunion, Rwanda, Seychelles, Somalia, South Sudan, Uganda, United Republic of Tanzania, Zambia, Zimbabwe

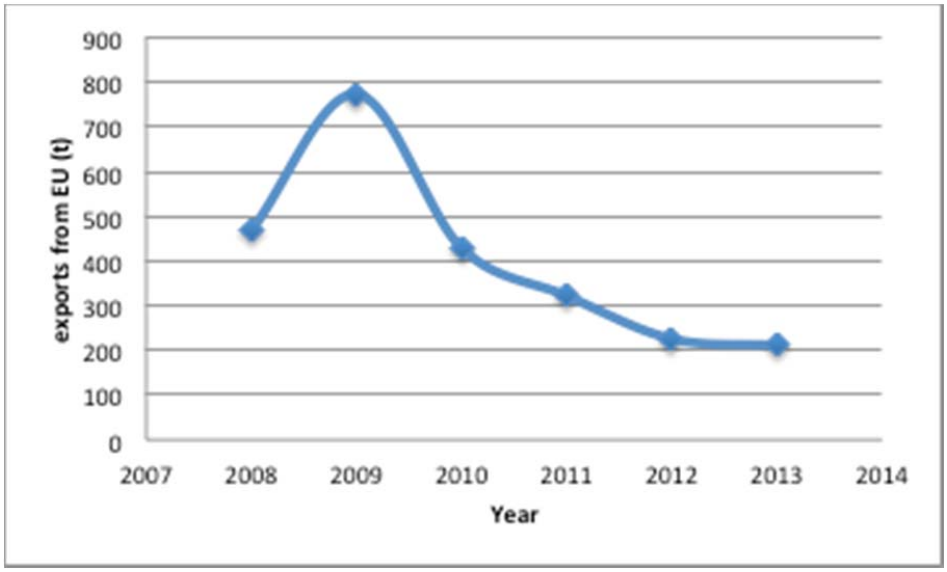
Overview

The detected exports to Eastern Africa represent an average of 0.4 kt/year for the period of 2008 to 2013, with a total value of 1.5 million euro. Interestingly, the exports show a declining trend from 2009 to 2013. Refrigerators and desktops mostly caused this decline. The relative share of the imports is significant in the area. For some individual countries, the imports can make up approximately half of the amounts of the e-waste generated. This is especially the case for the relatively small economies of Madagascar, Zimbabwe, Seychelles and the Commodores.

Main data table

Eastern Africa	Imports per year (tonnes)	Value (Million of Euros)	Share of imported products compared to waste domestically generated of the same appliances
Laptops and desktops	167	0.8	4%
Fridges and Freezers	184	0.1	3%
CRT screens	2	0.0	1%
Flat panel screens	43	0.2	4%
Mobile phones	4	0.4	1%

Time series of exports to Eastern Africa



4.4 EXPORTS TO CENTRAL AFRICA

Angola, Cameroon, Central African Republic, Chad, Democratic Republic of the Congo, Equatorial Guinea, Gabon, Sao Tome and Principe

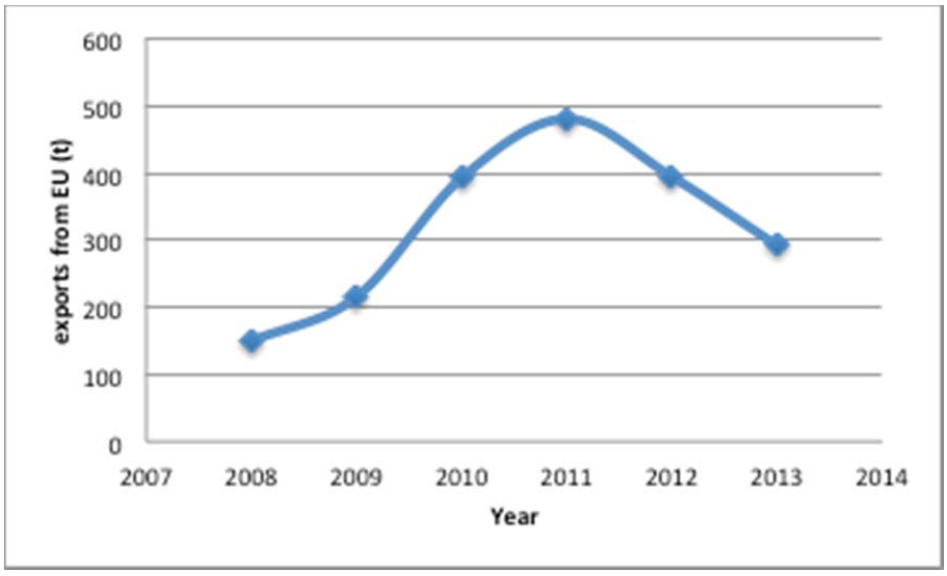
Overview

The detected exports to Central Africa represent an average of 0.4 kt/year for the period of 2008 to 2013, with a total value of EUR 2.0 million. The exports show an increasing trend from 2008 to 2011, and decline in 2012 and 2013. This trend is seen for all investigated products. The relative share of the imports is significant in the area. For the total region, it is approximately 5 per cent. For some individual countries, the imports make up approximately half of the market of the e-waste generated. This is especially true in the Central African Republic with refrigerators and for the relatively small country of Sao Tome and Principe with desktops.

Main data table

Central Africa	Imports per year (tonnes)	Value (Million of Euros)	Share of imported products compared to waste domestically generated of the same appliances
Laptops and desktops	103	0.5	5%
Refrigerators and Freezers	189	0.1	3%
CRT screens	9	0.0	0%
Flat panel screens	57	0.1	4%
Mobile phones	14	1.3	2%

Time series of exports to Middle Africa



4.5 EXPORTS TO NORTHERN AFRICA

Algeria, Egypt, Libya, Morocco, Sudan, Tunisia

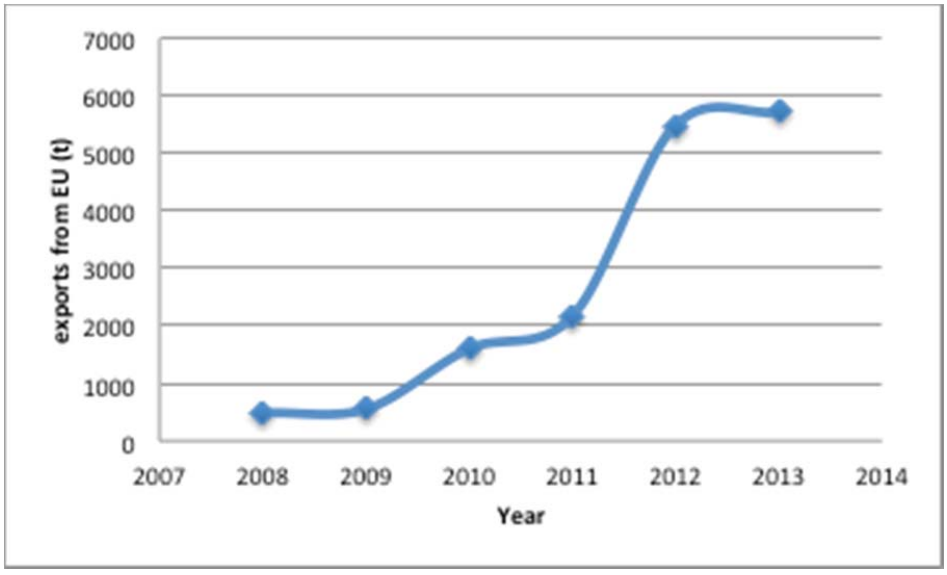
Overview

The detected exports to Northern Africa were relatively large, and represent an average of 2.4 kt per year for the period of 2008 to 2013, with a total value of EUR 20 million. The value is mostly dominated by laptops, desktops and flat panel displays. Those products are also responsible for most of the observed growth. The growth seems to stop in 2013. The relative share of the imports is very high in the area. It may be the case that the goods are imported into North Africa, being close to Europe, and then further transported to other parts of Africa. The top importing countries are Morocco and Egypt. Imports of second hand desktops make up around 20% of the e-aste market of desktops in Morocco and Egypt.

Main data table

Northern Africa	Imports per year (tonnes)	Value (Millions of Euros)	Share of imported products compared to waste domestically generated of the same appliances
Laptops and desktops	1,965	12.8	16%
Refrigerators and freezers	87	0.1	0%
CRT screens	39	0.1	1%
Flat panel screens	1,256	6.0	13%
Mobile phones	6	0.9	0%

Time series of exports to Northern Africa



4.6 EXPORTS TO SOUTHERN AFRICA

Botswana, Lesotho, Namibia, South Africa, Swaziland

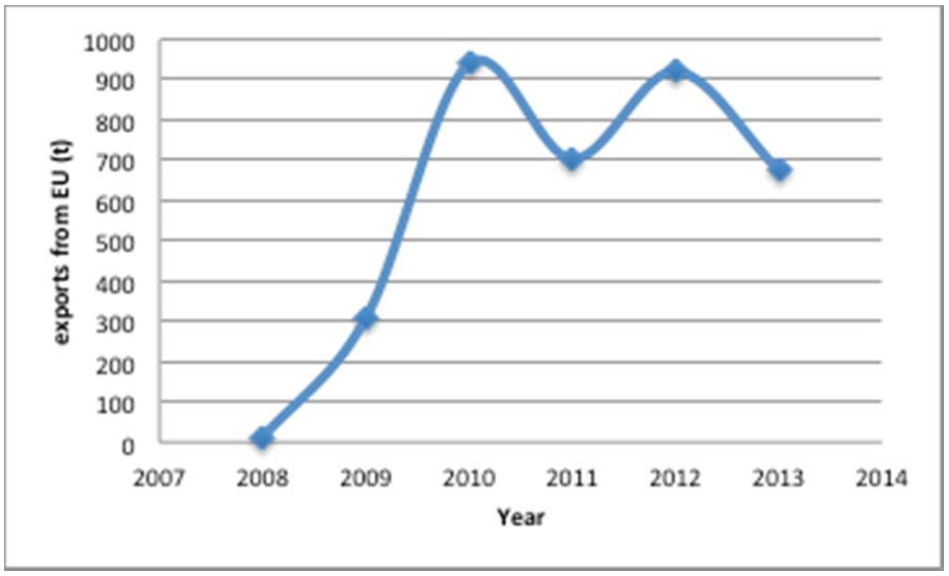
Overview

The detected exports to Southern Africa were very little–only 0.7 kt/year for the period of 2008 to 2013, with a total value of EUR 3.6 million. The value is mostly represented by desktops, which were mostly imported to South Africa. The imports increased from 2008 to 2010, and afterwards they were more or less stable. The relative share of those imports is very high in the area– at least 11 per cent. Next to the desktops, hardly any other significant exports of second-hand items or e-waste were detected.

Main data table

Southern Africa	Imports per year (tonnes)	Value (Millions of Euros)	Share of imported products compared to waste domestically generated of the same appliances
Laptops and desktops	694	3.4	11%
Refrigerators and freezers	3	0.0	0%
CRT screens	0	0.0	0%
Flat panel screens	14	0.1	0%
Mobile phones	2	0.1	0%

Time series of exports to Southern Africa



4.7 EXPORTS TO WESTERN AFRICA

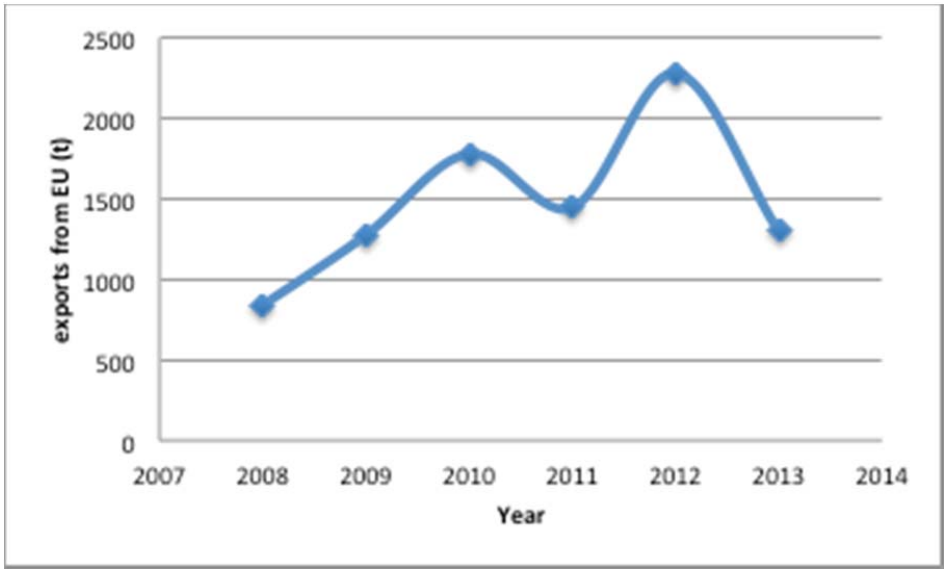
Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Saint Helena, Senegal, Sierra Leone, Togo

Overview

The detected exports to Western Africa represented 1.6 kt averagely per year for the period of 2008 to 2013, with a total value of EUR 4.2 million. The exports show an increasing trend from 2008 to 2010, and fluctuated afterwards. Most of trading was in refrigerators and freezers. The relative share of the imports was modest in the area. For the total region, it is approximately 3 to 4 per cent. For some individual countries, the imports make up approximately half of the market of the e-waste generated. This is especially true for the poorest countries in the region, such as Sierra Leone, Cote D'Ivoire and Niger. Most trade, in terms of physical goods, flow to Ghana, Nigeria and Mauritania. For Gambia and Guinea, the imports of freezers made up respectively 35% and 25% of the market of e-waste of freezers.

Main data table

Western Africa	Imports per year (tonnes)	Value (Millions of Euros)	Share of imported products compared to waste domestically generated of the same appliances
Laptops and desktops	255	1.6	4%
Refrigerators and freezers	1,192	0.8	4%
CRT screens	43	0.0	0%
Flat panel screens	141	0.4	3%
Mobile phones	14	1.4	0%



4.8 EXPORTS TO CENTRAL ASIA

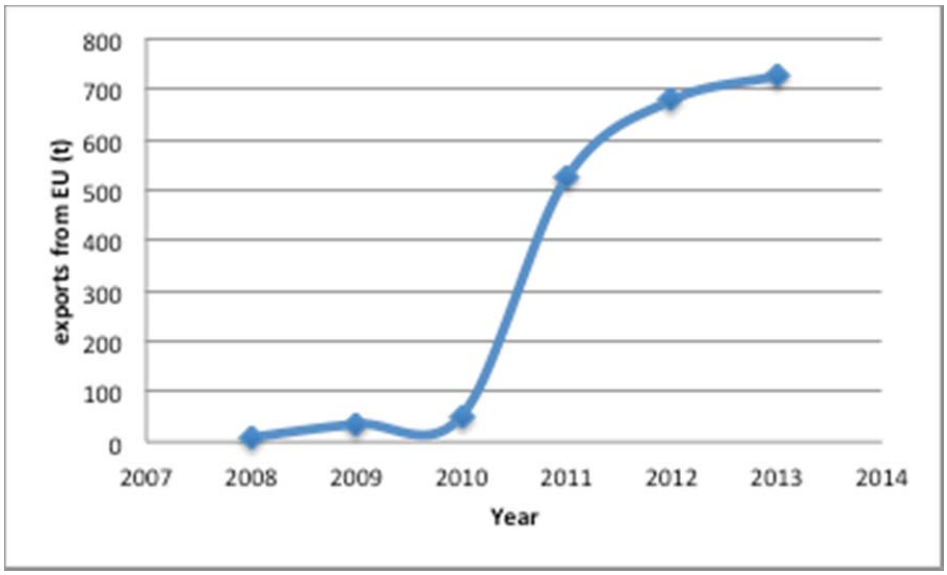
Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan

Overview

The detected exports to central Asia represent 0.5 kt/year for the period of 2008 to 2013, with a value of EUR 2.5 million per year. The exports show a rapid increasing trend from 2009 to 2013. Most of the trading was in refrigerators, which were mostly were imported into Uzbekistan, and to a lesser extent to Tajikistan. The relative share of the imports of second-hand equipment is expected to be modest in the area. For the total region, it is approximately 5 to 6 per cent.

Main data table

Central Asia	Imports per year (tonnes)	Value (Millions of Euros)	Share of imported products compared to waste domestically generated of the same appliances
Laptops and desktops	2	0.0	0%
Refrigerators and freezers	482	0.7	6%
CRT screens	0	0.0	0%
Flat panel screens	12	0.1	1%
Mobile phones	26	1.7	5%



4.9 EXPORTS TO EASTERN ASIA

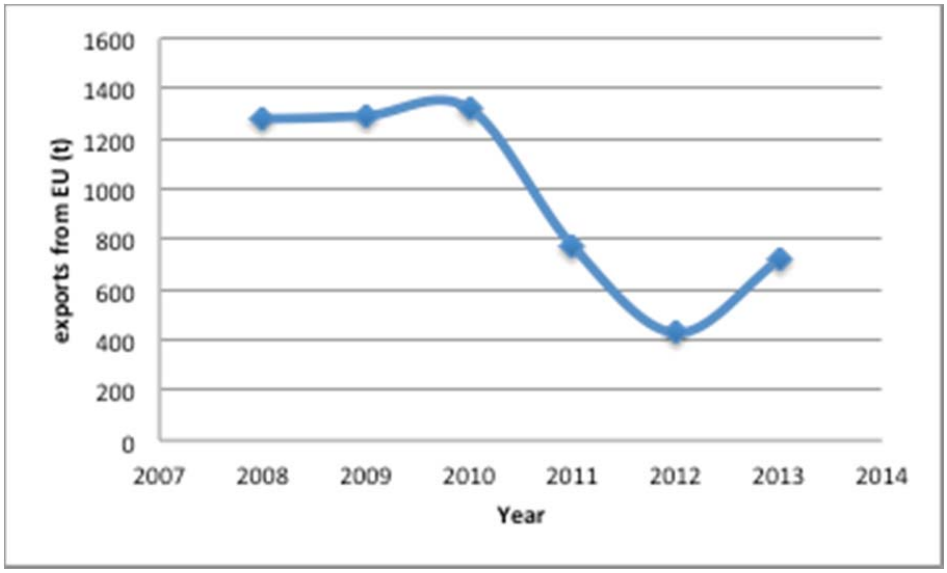
China, Hong Kong, Macao, Japan, Mongolia, Republic of Korea

Overview

The detected exports to eastern Asia represent an average of 0.9 kt/year for the period of 2008 to 2013, with a value of EUR 24.5 million per year. The exports show a rapid decrease trend from 2010 to 2012 (most likely due to the economic crisis), and then they started to grow again after 2012. Most of trading was caused by laptops in absolute weights, but value was predominantly represented by mobile phones (89 per cent of the value share). The reason could be that mobile phones have high value for both the refurbishment market and also for recycling the Li-ion batteries and the printed circuit boards. The relative share of the imports is very modest in the area, and it is almost 0 per cent for the entire region. The low percentage is due to the large domestic generation of e-waste market in China, which was the denominator of the calculated share in the table below. Most imports went to Hong Kong, which is the typical entry point for further trading and transport into Mainland China.

Main data table

Eastern Asia	Imports per year (tonnes)	Value (Millions of Euros)	Share of imported products compared to waste domestically generated of the same appliances
Laptops and desktops	512	2.0	0%
Refrigerators and freezers	3	0.0	0%
CRT screens	65	0.0	0%
Flat panel screens	177	0.6	0%
Mobile phones	186	21.9	0%



4.10 EXPORTS TO SOUTHEAST ASIA

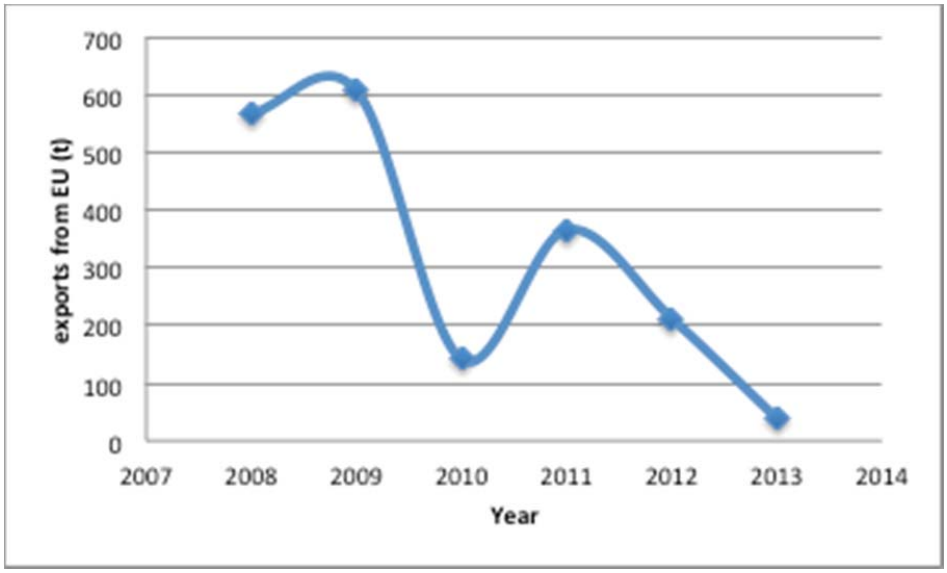
Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, Viet Nam

Overview

The detected exports to Southeast Asia represent an average of 0.4 kt/year from 2008 to 2013, with a value of EUR 0.6 million per year. The exports show volatile behavior; they rapidly decreased from 2009 to 2010, with a rapid increase from 2010 to 2011, and then decreased also from 2011 onwards. This is probably caused by the relatively small number of exports, which represents the "noise" in the analysis. CRT and flat panel screens in absolute weights represent most of trading, but the most value was created by computers (50 per cent of the value share). The relative share of the imports is very modest in the area–around 1 to 2 per cent for the whole region. It is interesting that there is still a substantial number of CRT being imported in this region (mostly to Thailand, Viet Nam, and to a lesser extent, Malaysia), which may imply that there is still demand for the CRT glass in closed-loop recycling in this region, or reuse demand for second-hand CRT screens.

Main data table

South-Eastern Asia	Imports per year (tonnes)	Value (Millions of Euros)	Share of imported products compared to waste domestically generated of the same appliances
Laptops and desktops	85	0.3	1%
Refrigerators and freezers	1	0.0	0%
CRT screens	138	0.0	1%
Flat panel screens	147	0.1	2%
Mobile phones	3	0.2	0%



4.11 Exports to Southern Asia

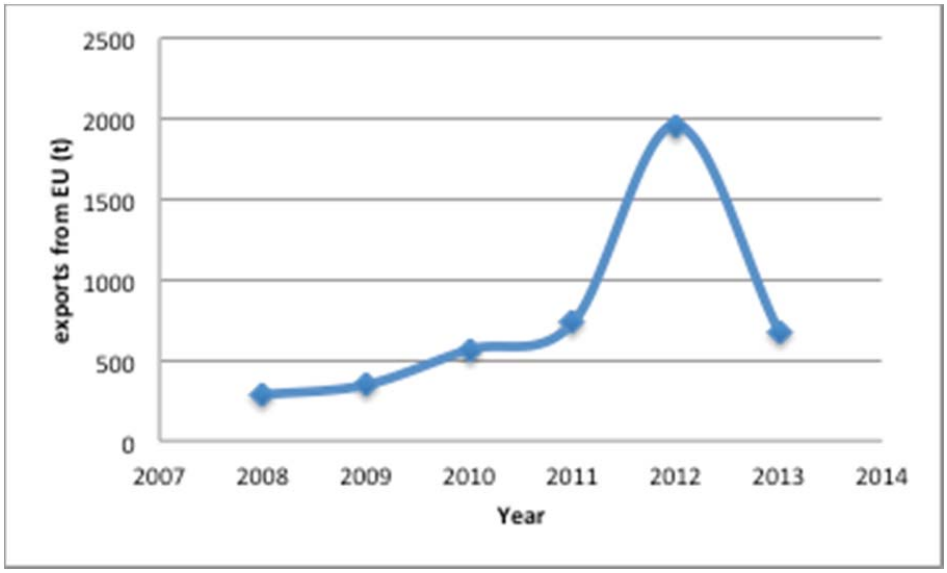
Afghanistan, Bangladesh, Bhutan, India, Iran (Islamic Republic of), Maldives, Nepal, Pakistan, Sri Lanka

Overview

The detected exports to Southern Asia represent an average of 0.9 kt/year for the period of 2008 to 2013, with a total value of EUR 2.8 million. The exports show a rapid increase trend from 2008 to 2012, but a rapid decrease after 2012. Most of trading was in computers in both absolute weight (71 per cent) and value (64 per cent). The relative share of the imports is very modest in the area, and it is around 1 to 2 per cent for the whole region. For some individual countries, the imports can make up a substantial portion of the market of the e-waste generated. For instance, the imported amount of laptops and desktops into Pakistan is equivalent to 8 per cent the waste generated of those appliances. Most trade in this region, in terms of physical goods, flows to Pakistan.

Main data table

Southern Asia	Imports per year (tonnes)	Value (Millions of Euros)	Share of imported products compared to waste domestically generated of the same appliances
Laptops and desktops	675	1.8	1%
Refrigerators and freezers	1	0.0	0%
CRT screens	67	0.1	1%
Flat panel screens	198	0.4	2%
Mobile phones	8	0.5	0%



4.12 Exports to Western Asia

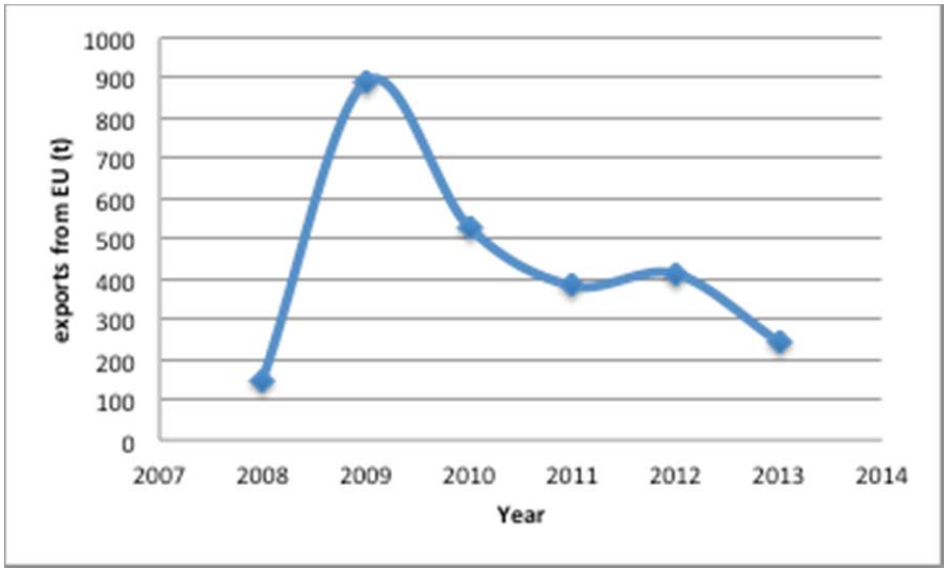
Armenia, Azerbaijan, Bahrain, Georgia, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, State of Palestine, Syrian Arab Republic, Turkey, United Arab Emirates, Yemen

Overview

The detected exports to Western Asia represent an average of 0.5 kt/year from 2008 to 2013, with a total value of EUR 11.5 million. The exports show a rapid decrease from 2009 to 2013. Most of trading in weight was in computers (36 per cent), however the most value was created by the mobile phones (84 per cent). The relative share of the imports is modest in the area, around 1 per cent for the whole region, but mobile phones make up 4 per cent of the total waste generation of domestic mobile phones. The value of the imported mobile phones is around 22 euro/item. The data indicates that there is a substantial market for second-hand mobile phones, or their fractions. Most trade, in terms of physical goods, flows to United Arab Emirates, Lebanon and Turkey. It is unclear whether these countries are final destinations, or merely function as hubs for further transportation.

Main data table

Western Asia	Imports per year (tonnes)	Value (Millions of Euros)	Share of imported products compared to waste domestically generated of the same appliances
Laptops and desktops	182	1.2	1%
Refrigerators and freezers	146	0.1	0%
CRT screens	12	0.1	0%
Flat panel screens	70	0.4	0%
Mobile phones	101	9.7	4%



4.13 Exports to South America

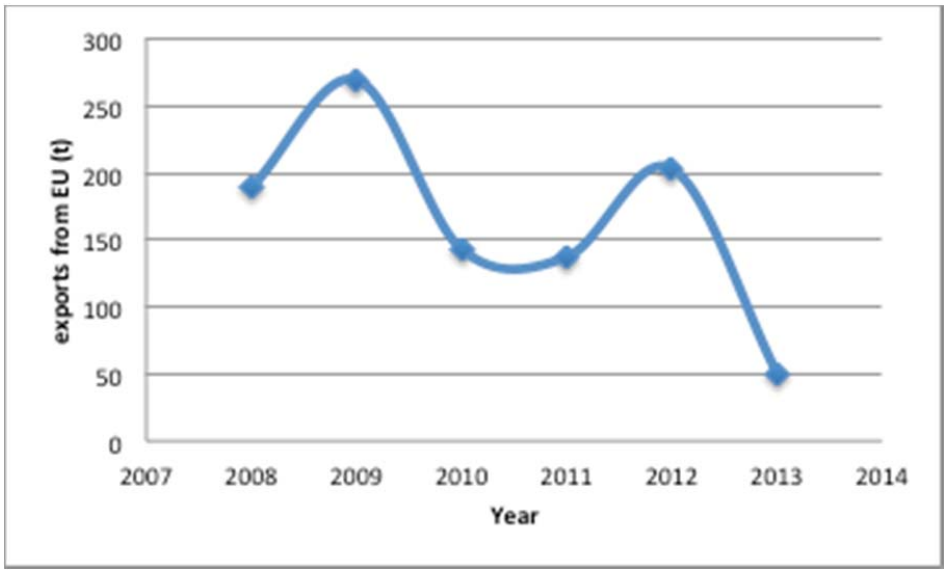
Bolivia (Plurinational State of), Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela (Bolivarian Republic of)

Overview

The detected exports to South America represent an average of 0.2 kt/year from 2008 to 2013, with a total value of EUR 0.8 million. The exports show a volatile behavior, most due to the noise of the analysis, as the absolute exports are very small because the region is far away from the EU. Most of trading was in computers in both absolute weight (70 per cent) and value (62 per cent). The relative share of the imports is modest in the area, and it is around 1 per cent for the whole region. Most trade, in terms of physical goods flow to Uruguay, Brazil and Chile.

Main data table

South America	Imports per year (tonnes)	Value (Millions of Euros)	Share of imported products compared to waste domestically generated of the same appliances
Laptops and desktops	119	0.5	1%
Refrigerators and freezers	2	0.0	0%
CRT screens	5	0.0	3%
Flat panel screens	42	0.1	0%
Mobile phones	1	0.2	0%



5 CONCLUSIONS

Amounts of exports

The analysis showed that the exports of used EEE and e-waste from the EU 28 Member States increased from 2008 to 2012, and there was a small decline through 2013 in terms of weight. The value of the exports from the EU-28 was dominated by mobile phones, which peaked in 2010. Afterwards, it flattened in 2011 and 2012, and increased in 2013 as well. Only 55 kt of exports were detected over the investigated timespan (2008 to 2013). This is most likely an underestimation of the total amounts exported as whole units from the EU-28.

Destination of exports

As expected, there were hardly any exports to Oceania, North America and South America. The trades within the EU were not analyzed. The trade shows a decreasing trend from 2008 to 2013 towards Eastern Asia, Western Asia, Southeast Asia and Eastern Africa. Other regions in the world showed an increasing amount of trade, including Central Asia, Southern Asia, Western Africa, Southern Africa, Northern Africa and non-EU Southern Europe. Regions that are close to Europe generally receive the most trade of used EEE and e-waste.

Origin of exports

Most exports came from Germany and Great Britain. It was remarkable that Estonia and Latvia exported considerable amounts of commodities compared to the size of the countries. Most of the imports were found in regions that are relatively close to the EU, such as Northern and Western Africa. In terms of the relative size of the receiving economies, large flows were found also to countries in the European region that were not member of the EU.

6 RECOMMENDATIONS TO IMPROVE MONITORING

The management of used (near EoL) EEE and e-waste is one of the most challenging issues in the world. This is essential to maximize efficient resources use, but also to mitigate negative environmental consequences and potential negative health effects. The quantities are moved across borders are increasing each year, and trading routes change over time due changes in the markets, imposed trading bans, changes in local e-waste management laws and changes in enforcement. This makes monitoring these flows increasingly important. A harmonized method to monitor these flows that is robust, builds on existing statistical principals and that can be applied frequently is therefore essential. To date, there are no internationally agreed upon definitions on how to classify the movement of e-waste and used EEE (near EoL EEE). For instance, the definition of waste differs between environmental and customs legislation, which hampers the harmonized trade registers to be used for statistics on the transboundary movement of e-waste and used electronics. Alignment of the environmental definitions of e-waste and of used electronics into the trade statistics would disclose much information that can be used to construct high quality statistics on the transboundary movement of e-waste and second-hand electronics. This data is essential for policymaking, which needs high quality statistics, and it would greatly facilitate the work on the ground for custom authorities and environmental inspection agencies in their efforts to verify the legal status of shipments. **Therefore, at least one code for e-waste, and one for used-EEE needs to be created on world level.**

With the absence of suitable trading codes for e-waste, other methodologies will have to be employed to indirectly reconstruct this type of data. This typically leads to less harmonized and incomplete datasets. This is why international harmonization is needed to, at a minimum, provide guidelines to measure trade of second-hand EEE and e-waste, and to construct more harmonized datasets than those currently available. **A methodology to determine trade of used-EEE and e-waste should align with the recently developed e-waste statistical guidelines developed by the Partnership on Measuring ICT for Development**. The methodology applied in this report is consistent with the current guidelines on e-waste statistics. The method is based on a distinction of the price of the trade, whether it is likely to be a trade of second-hand or waste commodities. It is a simplified version of the method originally developed by MIT, which allowed the UNU to scaling the method to include additional regions. This methodology could potentially be adopted by the Partnership on Measuring ICT for development and be applied in other regions as well, in order to create harmonized datasets with a worldwide coverage. **The to be developed datasets also need to be recent, which calls for international coordination to frequently update the e-waste statistics.**

The methodology relies on high-quality data with a high resolution, and it would not reflect the real quantities, but rather yield good estimates of the flows and their spatial direction. The ideal resolution would be the raw data on shipment level, which is potentially available at national statistical offices and custom offices. However in this study, only monthly aggregated data was currently available for each commodity (CN code) between two countries. It was discovered that the quality of this data was rather poor in the EU; in the current assessment, many records had to be discarded, as they were logically

invalid. For example some data contained an unrealistic average weight. By discarding these pieces of data, potentially valuable information had to be ignored. An additional check on the average weight was conducted using the entries of the physical units (the weight and number of units), and this was essential to perform prior calculating the price to detect the second hand trades. It is recommended to improve the data quality of the data reported to the authorities. **Another improvement would be if countries themselves statistical analysis on an enterprise level, which can be achieved through cooperation with ports, national statistical institutes or custom offices.**

7 ACKNOWLEDGEMENTS

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ANNEX 1

List of analyzed Combined Nomenclature codes and its descriptions and the boundaries of average weight

UNU-Key	CN	Description	Threshold price (euro/piece)	Boundaries of average weight (kg/piece)
0108	84181020	COMBINED REFRIGERATOR-FREEZERS, OF A CAPACITY > 340 L, FITTED WITH SEPARATE EXTERNAL DOORS	80	56 to 130
0108	84181080	COMBINED REFRIGERATOR-FREEZERS, OF A CAPACITY <= 340 L, FITTED WITH SEPARATE EXTERNAL DOORS	95	27 to 76
0108	84182110	HOUSEHOLD REFRIGERATORS, COMPRESSION-TYPE, OF A CAPACITY > 340 L	105	31 to 104
0108	84182151	HOUSEHOLD REFRIGERATORS, COMPRESSION-TYPE, TABLE MODEL	31	16 to 37
0108	84182159	HOUSEHOLD REFRIGERATORS, COMPRESSION-TYPE, BUILDING-IN TYPE	100	20 to 45
0108	84182191	HOUSEHOLD REFRIGERATORS COMPRESSION-TYPE, OF A CAPACITY <= 250 L (EXCL. TABLE MODELS AND BUILDING-IN TYPES)	37	21 to 41
0108	84182199	HOUSEHOLD REFRIGERATORS, COMPRESSION-TYPE, OF A CAPACITY > 250 L BUT <= 340 L (EXCL. TABLE MODELS AND BUILDING-IN TYPES)	37	22 to 60
0108	84182200	HOUSEHOLD REFRIGERATORS, ABSORPTION-TYPE	21	10 to 28
0108	84182900	HOUSEHOLD ELECTRICAL REFRIGERATORS, ABSORPTION-TYPE		
0109	84183020	FREEZERS OF THE CHEST TYPE, OF A CAPACITY <= 400 L"""	85	20 to 80
0109	84183080	FREEZERS OF THE CHEST TYPE, OF A CAPACITY > 400 L BUT <= 800 L"""	85	20 to 80
0109	84183091	FREEZERS OF THE CHEST TYPE, OF A CAPACITY <= 400 L (EXCL. THOSE FOR CIVIL AIRCRAFT OF SUBHEADING 8418.30.10)"""	10	20 to 80
0109	84183099	FREEZERS OF THE CHEST TYPE, OF A CAPACITY > 400 L BUT <= 800 L (EXCL. THOSE FOR CIVIL AIRCRAFT	10	20 to 80

		OF SUBHEADING 8418.30.10)"""		
0109	84184020	FREEZERS OF THE UPRIGHT TYPE, OF A CAPACITY <= 250 L"""	50	20 to 80
0109	84184080	FREEZERS OF THE UPRIGHT TYPE, OF A CAPACITY > 250 L BUT <= 900 L"""	100	20 to 80
0109	84184091	FREEZERS OF THE UPRIGHT TYPE, OF A CAPACITY <= 250 L (EXCL. THOSE FOR CIVIL AIRCRAFT OF SUBHEADING 8418.40.10)"""	10	20 to 80
0109	84184099	FREEZERS OF THE UPRIGHT TYPE, OF A CAPACITY > 250 L BUT <= 900 L (EXCL. THOSE FOR CIVIL AIRCRAFT OF SUBHEADING 8418.40.10)"""	10	20 to 80
0302	84714100	DATA-PROCESSING MACHINES, AUTOMATIC, COMPRISING IN THE SAME HOUSING AT LEAST A CENTRAL PROCESSING UNIT, AND ONE INPUT UNIT AND ONE OUTPUT UNIT, WHETHER OR NOT COMBINED (EXCL. PORTABLE WEIGHING <= 10 KG AND EXCL. THOSE PRESENTED IN THE FORM OF SYSTEMS AND	80	2 to 12
0302	84714900	DATA-PROCESSING MACHINES, AUTOMATIC, PRESENTED IN THE FORM OF SYSTEMS "COMPRISING AT LEAST A CENTRAL PROCESSING UNIT, ONE INPUT UNIT AND ONE OUTPUT UNIT" (EXCL. PORTABLE WEIGHING <= 10 KG AND EXCL. PERIPHERAL UNITS)	80	3 to 16
0302	84715000	PROCESSING UNITS FOR AUTOMATIC DATA-PROCESSING MACHINES, WHETHER OR NOT CONTAINING IN THE SAME HOUSING ONE OR TWO OF THE FOLLOWING TYPES OF UNIT: STORAGE UNITS, INPUT UNITS, OUTPUT UNITS (EXCL. THOSE OF HEADING 8471.41 OR 8471.49 AND EXCL. PERIPHERAL UNIT	80	3 to 18
0303	84713000	DATA-PROCESSING MACHINES, AUTOMATIC, PORTABLE, WEIGHING <= 10 KG, CONSISTING OF AT LEAST A CENTRAL PROCESSING UNIT, A KEYBOARD AND A DISPLAY (EXCL. PERIPHERAL UNITS)	54	1 to 6

0306	85171200	TELEPHONES FOR CELLULAR NETWORKS "MOBILE TELEPHONES" OR FOR OTHER WIRELESS NETWORKS	20	0 to 1
0308	85284100	CATHODE-RAY TUBE MONITORS OF A KIND SOLELY OR PRINCIPALLY USED IN AN AUTOMATIC DATA-PROCESSING MACHINE OF HEADING 8471	30	1 to 14
0309	85285100	MONITORS OF A KIND SOLELY OR PRINCIPALLY USED IN AN AUTOMATIC DATA-PROCESSING MACHINE OF HEADING 8471 (EXCL. WITH CATHODE RAY TUBE)	60	2 to 20
0309	85285940	MONITORS, COLOUR, NOT INCORPORATING TELEVISION RECEPTION APPARATUS, WITH LCD SCREEN (EXCL. THOSE OF A KIND SOLELY OR PRINCIPALLY USED IN AN AUTOMATIC DATA-PROCESSING SYSTEM OF HEADING 8471)	10	1 to 4
0309	85285980	MONITORS, COLOUR, NOT INCORPORATING TELEVISION RECEPTION APPARATUS (EXCL. WITH LCD SCREEN OR CATHODE RAY TUBE AND THOSE OF A KIND SOLELY OR PRINCIPALLY USED IN AN AUTOMATIC DATA-PROCESSING SYSTEM OF HEADING 8471)	8	1 to 4
0407	85284980	CATHODE-RAY TUBE MONITORS, COLOUR, NOT INCORPORATING TELEVISION RECEPTION APPARATUS (EXCL. OF A KIND SOLELY OR PRINCIPALLY USED IN AN AUTOMATIC DATA-PROCESSING SYSTEM OF HEADING 8471)	25	15 to 50
0408	85287220	RECEPTION APPARATUS FOR TELEVISION, COLOUR, INCORPORATING A VIDEO RECORDER OR REPRODUCER	25	6 to 25
0408	85287291	RECEPTION APPARATUS FOR TELEVISION, COLOUR, WITH SCREEN, WITH A SCREEN WIDTH/HEIGHT RATIO < 1,5 (EXCL. WITH INTEGRAL TUBE OR INCORPORATING VIDEO RECORDING OR REPRODUCING APPARATUS AND	25	6 to 25

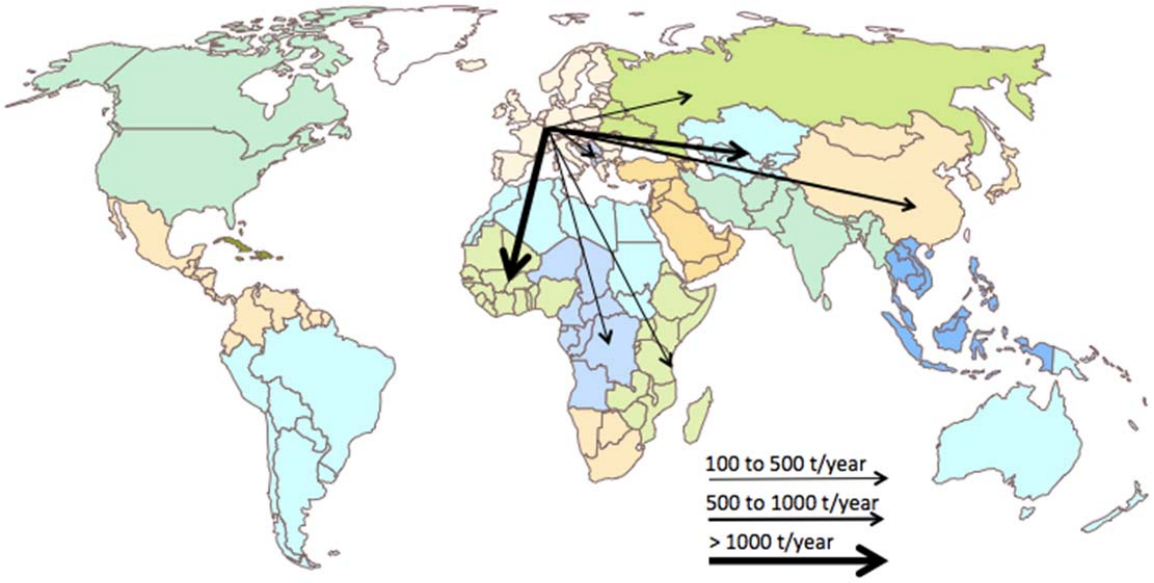
		MONITORS)		
0408	85287299	RECEPTION APPARATUS FOR TELEVISION, COLOUR, WITH SCREEN, WITH A SCREEN WIDTH/HEIGHT RATIO >= 1,5 (EXCL. WITH INTEGRAL TUBE OR INCORPORATING VIDEO RECORDING OR REPRODUCING APPARATUS AND MONITORS)	25	6 to 25

ANNEX 2: DESTINATION OF EXPORTS FROM THE EU

Refrigerators and freezers

The main destination for refrigerators and freezers in the world are Western Africa (1100 t / year) and Central Asia (319 t/year), closely followed by Eastern Africa (216 t/year) and Central Africa (172 t/year). The average price level of the exports is roughly 40 euro per item. The exports originate from Germany, Denmark and Lithuania.

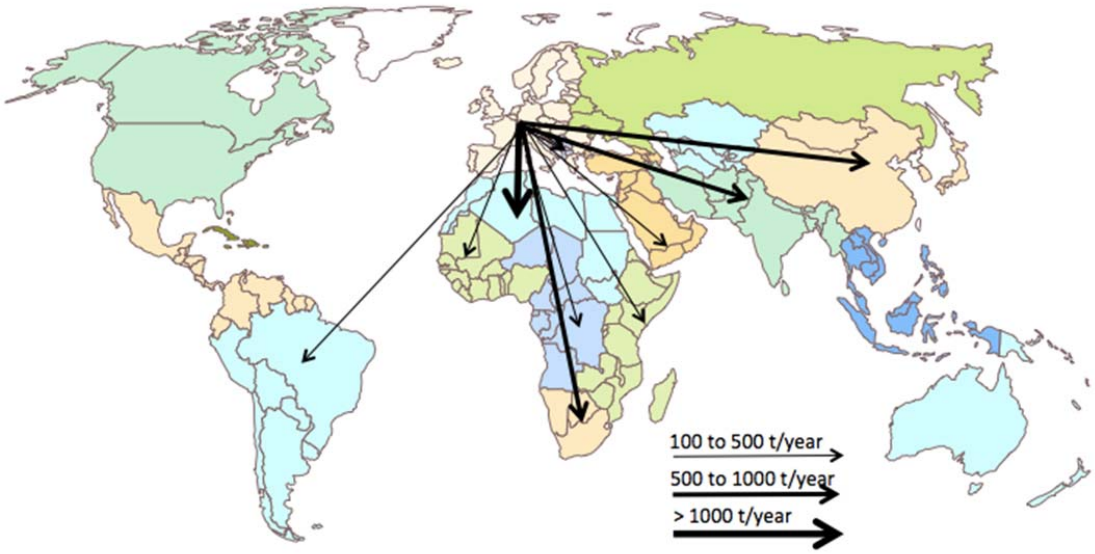
Figure 1: Major flows of refrigerators and freezers



Laptops and desktops

The main destination for laptops and desktops from the EU are Northern Africa (1700 t/year) and Southeast Asia and Eastern Asia (both 500 t/year). The average export price level increased from 27 euro per item in 2008 to 36 euro per item in 2013 per item for desktops of 37 euro per item. The exports most often originate in Great Britain, Germany and Poland.

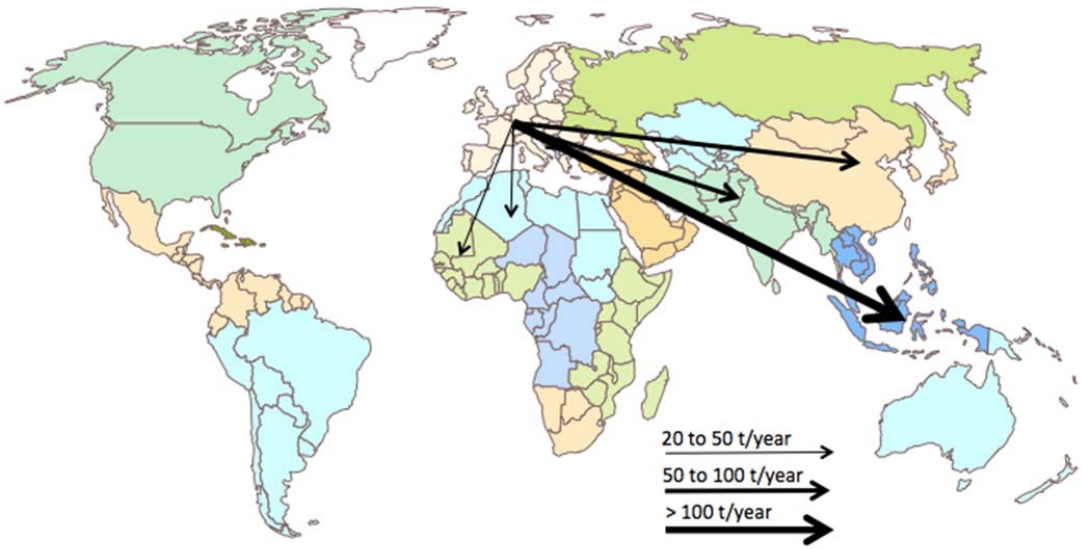
Figure 2: Major flows of laptops and desktops



CRT displays

The main destinations for CRT displays from the EU are South-Eastern Asia (130 t/year) and Southern Asia (70 t/year). The average price level of the exports hovered around 10 euro per item. Most exports originate from Great Britain, Estonia and Italy.

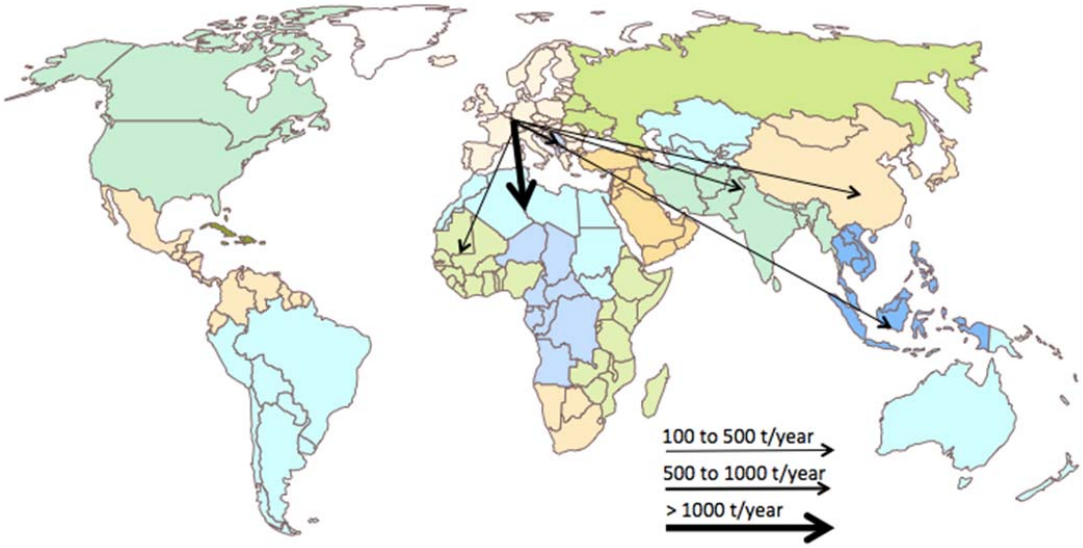
Figure 3: Major flows of CRT displays



Flat panel displays

The main destinations for flat panel displays are close to the EU; most exports go to Northern Africa (1300 t/year) and to non-EU Southern Europe (220 t/year). The average price level of the exports fluctuates between 20 and 30 euro per item. Most exports originate from Germany and Great Britain.

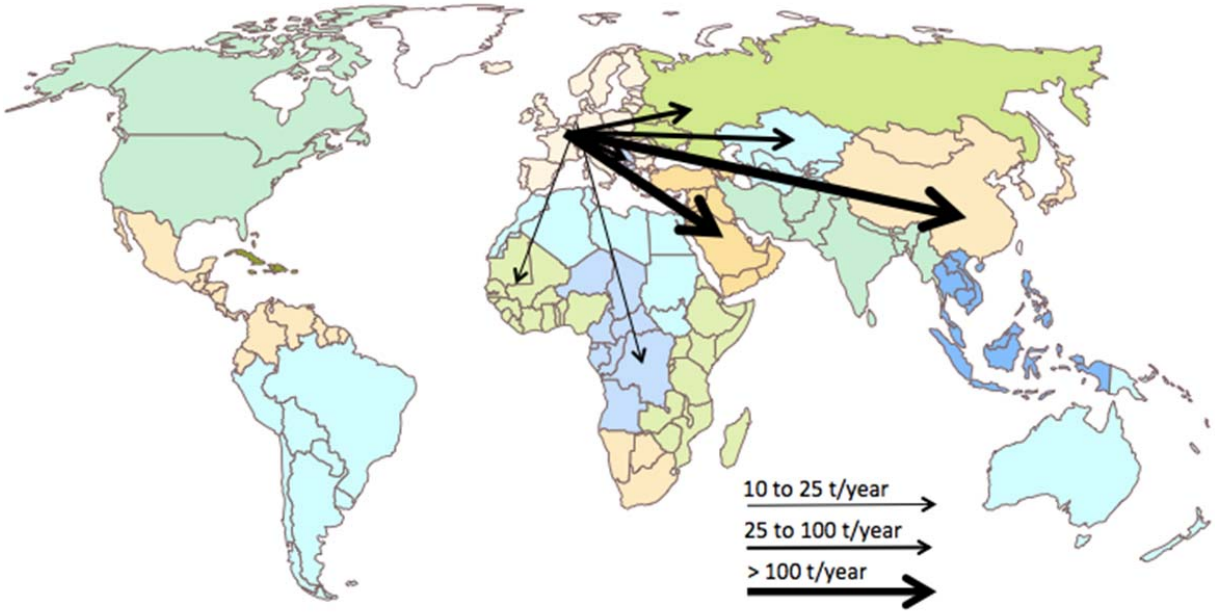
Figure 4: Major flows of flat panels



Mobile phones

The main destinations for flat panel displays are close to the EU; most exports go to Northern Africa (1300 t/year) and to non-EU Southern Europe (220 t/year). The average price level of the exports fluctuates between 20 and 25 euro per item. Most exports originate from Romania and Estonia.

Figure 5: Major flows of mobile phones



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