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WOT? Insights into the Flows and Fates of E-waste in the UK.

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Abstract: In 2019 the EU Waste Electrical and Electronic Equipment (WEEE) Directive documented a sizable increase in e-waste collection targets alongside a wider scope of electronic and electrical products covered by the legislation. These changes have significant impact for the UK, as for the past two years UK waste collected has failed to meet the newly adopted set of targets. Understanding the flows and fates of products on and off the market becomes of paramount importance, especially for producer-led organisations who have the responsibility to achieve the targets and cover the operational costs. Historic e-waste estimation methods often assume that one product on the market will equate to one product in the waste stream. In this article, we report on a project commissioned by one of the largest UK producer-led organizations – REPIC Ltd, in search of an explanation of the observed drop-in products on the market and WEEE collected, and the relationship between the two. We argue that we should move away from "one product in and one product out" assumption to include wider parameters that are tailored specifically for the UK, including those linked with the state of the market for electronic and electrical products and of the wider economy, examples include inflation-adjusted GDP per capita, consumer confidence index (CCI), inflation indices (CPI or RPI), number of households, wealth distribution etc. We show how this can be achieved by adapting a state-of the-art e-waste estimation model (Waste Over Time) to the UK context and developing it further to include additional drivers.

Introduction

In 2019, the European Union's Waste of Electrical and Electronic Equipment (WEEE) Directive (2012) documented a substantial increase to the waste collection targets for EEE products Placed on the Market (POM). In addition, the scope of products covered by the legislation increased (European Commission, 2017), to include all EEE unless otherwise stated (Defra, 2017; Defra, 2018), which is referred to as Open Scope. Setting realistic and robust targets is fraught with difficulty due to the current consumer economy and multifaceted routes to disposal (e.g. second-hand markets, incorrect disposal in household bins, theft etc.), among other factors (Borthakur and Govind, 2017; Dindarian et al., 2012). These changes have significant implications for the UK, as the legislation is transposed into UK WEEE Regulations, as the recently published 2017 Environment Agency data[1] showed a drop both in EEE POM and waste EEE collected relative to 2016 in the UK. This trend continued in 2018. At the same time, "the proposed overall UK WEEE collection target for 2019 is 550,577 tonnes – over 57,000 tonnes higher than the total amount of household WEEE collected and reported in 2018". (REPIC 2019: para. 2).

With the Directive being premised on the principle of Extended Producer Responsibility (EPR), this places accountability, collection and funding for the end of life products with manufacturers (producers) and retailers. Therefore, understanding the economic life-cycle and value of products is vital for producer-led organisations. With the reliance on historical data (Van Straalen, 2016), the changes in post-consumer disposal practices (Borthakur and Govind, 2017; Dindarian et al., 2012) provides the opportunity to re-interrogate the flows of EEE and fates of WEEE in order to see how these changes can contribute to target setting and policy delivery (Stowell, Yumashev, et al., 2018).

[1] Data is available from https://www.gov.uk/government/statistical-data-sets/waste-electrical-and-electronic-equipment-weee-in-the-uk.

In this article, we report on a project commissioned by one of the largest UK producer-led organisations' – REPIC Ltd. One of their aims is to better understand WEEE target setting and the fate of used consumer EEE goods. In search of an explanation of the drop-in POM and waste EEE collected, this project's main aim was to investigate the relationship between the two. Building upon previous academic studies enhancing the estimations of e-waste (Wang et al., 2013; Magalini et al., 2016; Van Straalen, 2016) and industry research (WRAP, 2011; 2012; 2016), we sought to understand, this phenomena in further depth.

Our two key findings suggest that, first of all, the amount of WEEE available for collection needs to be determined for legislative targets. Unreported EEE and WEEE flows (in particular unregistered sellers placing EEE onto the UK market for the first time and via second-hand markets), along with changes in EEE product weight, product design lifespan and/or its household residence time,[2] are the key factors to take into consideration to design better compliance targets, understand the implications of Open Scope, and help improve the overall WEEE recycling rates.

Second, in order to accurately predict WEEE generated, detailed production, trade, age distributions of the products in the household and in the waste stream, and unit weight data should all be taken into consideration, including trends in all these parameters. In support of Wang et al. (2013), we also argue that there is a need for a new dynamic WEEE model, which has the ability to estimate annual fluctuations in POM and waste generated (WG) in response to wider socio-economic conditions and specific EEE market conditions. We conclude by putting forward a proposal for what this model could look like, building upon current state-of-the-art model for WEEE generated (Van Straalen, 2016), and show how e-waste estimates could be improved as a result.

Results and Relevance

Unreported flows – survey

As part of the project, we conducted surveys of EEE producers, retailers and those operating in the reuse or recycling space. The results of the surveys included individual product line or aggregate category-level estimates for residence times, unregistered sellers, product trends and other factors.

The key challenges for WEEE management stated by producers and collectors include:

- Unreported flows, second-hand markets, weight changes in products, differences in product design lifespan and household residence times (including hoarding), and component part removal/theft were indicated as factors that could impact the differences between WG and waste collected and cause an imbalance in National Target setting for PCSs.
- Ever-tightening restrictions on hazardous - chemicals in new EEE products will further limit the viability and demand for recycled materials from WEEE, at least for the manufacture of new EEE. An example of this is legacy POPs in plastics.
- The UK market has limited processing capacity for cooling equipment. There has been no mapping of the capacity requirements available and necessary to meet higher collection targets. Objectively assessing future demand for infrastructure would enable, alongside other measures, some certainty in investment.
- Scrap metal and iron spot price volatility affect the profitability of the dismantling of end of life appliances. If spot prices are high, the PCS access to WEEE reduces as products with high metal content such as LDA becomes more attractive to other actors, including for illegal export. Conversely, when spot prices fall, other actors can be driven to illegally remove the higher value components only, leaving a lighter carcass to be recycled.
- Retailers, and others, in the market may conduct activities that indirectly restrict access to WEEE by PCSs. For example, retailers collect old products on home delivery for a fee paid by the consumer, so they have an income stream to offset the cost of collection.

[2] Period between product purchase and its disposal as e-waste.

- Small appliances are less viable to reuse, with the exception of mobile phones, tablets etc. New goods continue to be put on the market at low cost and with limited durability. This means low value items should be more likely to arise in the WEEE stream. However, the official UK figures indicate this does not always happen, most likely due to the small size of the product making it easier to hoard/store or being discarded in the household waste bin.
- Collection undertaken by third parties involved in reuse and/or recycling and not financed by PCSs may not be reported in the official system, e.g. some small-scale operations operating under an exemption may not be an AATF or associated with one that can issue evidence.
- Socio-economic changes, for example, Brexit, Circular Economy (CE), inflation, labour costs, business rates and material pricing all impact on where WEEE flows and how accessible it is to a PCS.
- Future innovation and technological trends could be crucial for managing WEEE. Examples include artificial intelligence, network connected vehicles, voice recognition, Internet of Things, security products, etc.
- Understanding reuse, particularly in the context of the CE package, will be an increasingly important factor in assessing WEEE targets.

UK EEE and WEEE data, models and methodologies

Table 1 below summarizes the key policies and product categories considered in our study. The best available (W)EEE forecasting model, Waste Over Time (WOT), uses historic sales data expressed for 54 UNU product categories, in combination with product lifespan or residence time distributions (Van Straalen, 2016). However, the output of the model has not previously been tailored for the 14 UK (W)EEE categories. This is one of the main gaps that our project addressed by going to the more granular CN product level (Table 1).

Key Policies
EU WEEE Directive (2012/19/EU)
UK WEEE Regulation (2013)
Implementation Regulation (2017/699)
Move to Open Scope (2019)
Product Categories and Codes
6 EU Open Scope Categories
14 UK WEEE Categories
54 United Nations University (UNU) Codes (referred to as “UNU keys”)
500 PRODCOM (PCC) Codes (approx.)
1150 Combined Nomenclature (CN) Codes (approx.)

Table 1. Key policies, product categories and codes.

One drawback of current methods is that the residence time distributions are fixed based on the year of sale. However, in reality, these distributions are likely to change due to various factors, such as economic influences, consumer preferences and new product developments (or lack thereof). The prototype dynamic model developed during the project, which is described below provides a feasible way of rectifying this shortcoming.

Adapting state of the art model to the UK context

The project team identified two extensive lists of CN product codes relevant to UK EEE market: WEEE Europe (which has CN codes mapped onto UNU and UK categories, prepared by WEEE Europe in conjunction with REPIC) and WOT (with mappings onto PCC and UNU codes, but no UK categories). These lists have 671 and 762 and CN codes, respectively, of which 292 codes overlap, while the rest are unique to each of the two lists. Combined, the two lists contain around 1150 unique CN codes.

Following these findings, REPIC reviewed all the CN codes from the two lists combined, assigning UK codes to the WOT CN codes not on the WEEE Europe list for the first time, and updating the UK codes for the WEEE Europe list (part of which overlaps with WOT). REPIC also indicated possible changes to the CN-UK mapping due to the implementation of Open Scope. This was a difficult and sometimes ambiguous task given the terms used to describe the CN codes and the on-going development of the UK guidance on scope. This assessment is, therefore, on-going.

The analysis of the CN-UK mapping defined by these lists showed that multiple UNU keys map to 2 or more of the 14 UK categories. Therefore, to convert the WOT model output for POM and WG, which is provided at the UNU level, into 14 UK categories, special mapping protocols are required. The protocols are different for POM and WG, with the latter relying on the former, and both types of protocols are time-varying, which reflects on the evolution of the individual products and aggregate categories with time.

Exploring crucial improvements of the model to aid understanding

As mentioned earlier, the current generation of the WEEE quantification tools, such as the WOT model, are based solely on historic EEE POM and products' residence times (Van Straalen et al., 2016). Although the POM data in these tools captures historic variations in production and trade across a wide range of products, there is no underlying economic model to link these variations with wider socio-economic conditions. Moreover, the residence times are largely static, implying that the results for WG are smooth and do not reflect on year-on-year fluctuations in the WEEE arising observed in the official data. Therefore, the key suggested feature of a new model, which will build on the existing WEEE tools, is the ability to estimate annual fluctuations in POM and WG in response to varying wider socio-economic conditions and specific EEE market conditions in the UK.

The wider socio-economic parameters will include UK's inflation-adjusted GDP per capita, consumer confidence index (CCI), inflation indices (CPI or RPI), number of households, wealth distribution across the population, percentages of households with no or multiple units of a given product, number of businesses owning a given product, etc. The specific EEE market parameters will include inflation-adjusted prices of a given EEE product and other replacement, as well as new market drivers that affect the sales.

The model would build on the existing body of qualitative and quantitative research on EEE markets to derive statistical relationships between the socio-economic and market conditions introduced above, and the products' annual sales, stock and residence times. Where the data is not available, the quantifications of the proposed relationships will have to rely on tailor-made surveys across the EEE sector.

To achieve the best possible description, the model could be configured to operate on the CN or PCC product levels. However, calibrating all the necessary parameters for the hundreds of EEE products described by these codes, especially when it comes to defining variable residence times, would require a considerable effort. Therefore, it is sensible to consider aggregate categories such as UNU keys. The results could then be aggregated to UK14 categories.

Conclusions

Our research enhanced UK e-waste estimations through the adaption of the current EU-wide Waste Over Time (WOT) model for WG. This required special new protocols to be developed that map weight flows from one set of aggregate EEE categories to another. The protocols improve our understanding of how the aggregate EEE categories adopted in the UK and EU relate to the underlying granular product databases in the trade statistics (Eurostat), which includes the time-evolution of the mapping as old products get disconnected and new ones enter the market.

Our results compliment previous industry studies with some similar findings (WRAP, 2011; 2012; 2016). Overall, collecting data within the following areas should be prioritized:

-Mass balance – missing components (e.g. compressors, hard-drives etc.) and changing product weights should be better represented;

-Product lifespan and residence times – more information needs to be gathered from households and e-waste collectors since current data mostly comes from producers;

-Unreported flows – further insights into second-hand or used EEE, as well as legal and illegal WEEE flows are required.

Capturing products as they enter the market, their weight and their fates gives insights into EEE POM and WG trends. The collation of product weight, in particular, would also provide the ability to estimate future protocols for substantiated estimates, e.g. Small Mixed WEEE and Large Domestic Appliances metal scrap, or identify the need to develop the new protocols. Accurate information regarding product lifespan and residence times would give much needed insights into time horizons from EEE POM to WG. In addition, gathering further intelligence on unreported flows will identify system losses and possible entry points for unregistered sellers.

These new insights could help redirect the flows of EEE POM and WEEE, e.g. by boosting the demand for secondary materials from WEEE and/or by stimulating growth in the second hand or used EEE sector. The desired outcomes of these investigations are especially important given the UK's Circular Economy and Clean Growth strategy (BEIS, 2017; Defra, 2017), which includes an ambitious target to achieve zero waste by 2050.

In conclusion, we argue that in order to have a more robust understanding of UK EEE and WEEE flows there is a need to move beyond the "one product in and one product out" assumption to include:

- historic production and trade statistics, in combination with product residence time distributions that can be derived from the surveys of household stock and collected e-waste
- outputs for EEE POM and WG that are tailored for the 14 UK Categories
- socio-economic factors that reflect consumption trends
- market and technology trends that impact on purchase, weight, end of life patterns, reuse and recycling
- better quantification of the fates of WEEE which are unreported or unknown.

Achieving these goals would be beneficial both to (W)EEE practitioners operating and researchers focusing on e-waste estimations regardless of EU member state.

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