Technologies for circularity – Challenges in mapping and monitoring

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Within the broader scheme of environmental sustainability goals, circularity figures prominently on the policy agenda. In March 2020, the European Commission adopted the new circular economy action plan (CEAP), as one of the main building blocks of the European Green Deal. The transition towards a circular economy should reduce pressure on natural resources and will create sustainable growth and jobs. It is at the same time a prerequisite for achieving the EU's 2050 climate neutrality target. Circular economy is defined by the European Commission (2021) as "*a system which maintains the value of products, materials and resources in the economy for as long as possible, and which minimizes the generation of waste. This means a system where products are reused, repaired, remanufactured or recycled*". Clearly, circularity goes beyond recycling. Recycling is "end-of-pipe", while a circular economy goes upstream to avoid and address potential problems at earlier stages: preventing waste, to try and avoid the need to recycle.

From a policy perspective, adequately mapping and monitoring progress towards the circular economy hence becomes imperative. It is clear that the circular economy is a broad and multi-faceted concept, with many intricate mutual connections between elements. This poses considerable challenges for mapping and monitoring. One entry point is the consideration of separate components of the system. With technology being an essential enabler in the circularity economy, we focus on the measurement of technologies for circularity. The biggest challenge in this respect is delineation: how to identify patents in the domain of circularity? One relatively straightforward way is to consider technologies directly situated in the core domains of circularity: waste management technologies; technologies for resource collection, purification, storage and conservation; pollution abatement technologies; renewable energy technologies,… At the same time, several technologies for other purposes exist that may indirectly contribute to materials, processes and machinery that enable circularity (consider for example digital technologies as enablers of the digital-green twin transition).

Several delineations have been developed already. Three of the most widely used are WIPO's IPC Green Inventory (based on +/- 5000 IPC codes), EPO's Y02 tagging scheme for Climate Change Mitigation technologies (based on +/-300 CPC codes) and OECD's Environmental Technology scheme (based on a combination of 1000 IPC codes and 250 CPC codes). In order to assess which delineation to select (and whether it even matters), we extracted EPO patent applications for EU-27 countries (2012-2022) for each of the three delineations, and we compared coverage and resulting indicators between the delineations.

In terms of overlap between patent volumes, it is shown that the EPO and OECD classifications are highly overlapping. This is primarily due to their shared CPC codes. The WIPO delineation clearly reveals a broader picture, especially in Data processing and measurement systems; Genetic engineering, Horticulture; Nuclear physics and engineering. Also on the level of derived indicators, the resulting pictures vary according to the specific delineations used. The trend in the proportion of circular technologies in EU-27 between 2012 and 2022 remains stable, for all three delineations, but this proportion is structurally higher for the WIPO delineation than for both other delineations. On a micro-

level, considerable changes are revealed in the top 25 applicants in circular technologies, depending on which delineation is used. The same holds for country rankings. Hence, although there is considerable overlap in the existing delineations, switching between them implies non-trivial shifts in indicators on a micro and micro level. Thorough consideration should be given to the selection of the adequate delineation, tailored to the purpose of the mapping and monitoring.

In line with the above contention that there are core and enabling technologies for circularity, an additional validation was done to evaluate the extent to which the existing delineations actually capture circular technologies. More specifically, three companies were considered that specialize in developing machines and procedures for sorting materials (Tomra, Trinamix and Valvan). Contributing to the circular economy by facilitating the recycling process, is a core mission advanced by these companies. As such, one would expect that their patent portfolios are identified as belonging to circular technologies. Our analyses however reveal that less than 20% of these companies' patent portfolios are captured by the existing delineations. A more detailed and content-level consideration of their patent portfolios shows that these patents are in other domains that can indeed enable the development of sorting processes and machinery (e.g. infrared sensors; spraying nozzles; suction grippers; electrical components;…).

We conclude that existing delineations are useful building blocks, but that they do not provide the full picture. There is room for refinement, whereby ideally, the result would be a modular and transparent classification scheme for circular technologies. Technologies for other purposes (or more general purpose technologies) can be enabling for circularity and should not be ignored within such a classification scheme. At the same time, these technologies can also serve non-circular (or even counter-circular) purposes. A crucial point in this respect is the extent to which users of those technologies translate them into applications that effectuate circularity; and whether or how this can be enforced.

Indeed, circularity is an encompassing concept, going beyond the technicality of processes, and revolving around the value chain and architectural innovations. As such, the development of circularity-enabling technologies is a necessary but not a sufficient condition for achieving a circular economy. It is essential to bear this in mind when designing mapping and monitoring systems, and when deriving policy implications from them.