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UNRAVELLING INDIA'S E-WASTE SUPPLY CHAIN: A COMPREHENSIVE ANALYSIS AND MAPPING OF THE KEY ACTORS INVOLVED

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EXECUTIVE SUMMARY

India's rapid technological growth has significantly increased electronic consumption, resulting in a surge in electronic waste (e-waste) generation. Consequently, the rising e-waste in the country has necessitated the immense need for a proper e-waste management system in India. E-waste has always been considered a threat to the environment, as it contains toxic materials such as lead, cadmium, etc. The leakage of these toxic chemicals is suspected to cause air, water, and land pollution, and they are also vulnerable to human health hazards. This paper examines the complexities of India's e-waste supply chain focusing on key components and actors involved, such as consumers, manufacturers, retailers, recyclers, government agencies, and regulatory bodies, with an emphasis on the dominant role of informal players in the supply chain. Informality in the e-waste supply chain refers to the involvement of unregulated or informal actors and practices in the collection, recycling, and disposal of electronic waste. Despite the challenges posed by informality, it remains a significant aspect

of the e-waste management landscape, particularly in regions with limited formal infrastructure and enforcement mechanisms. Informal sector workers are often marginalized by society and may be referred to by unfavourable terms, including 'scavengers', 'rag pickers', and 'waste pickers'. The informal segment within the e-waste value chain retains its significance owing to its capacity to create employment opportunities. There is a need to integrate the activities of the informal sector into the mainstream recycling of e-waste by dovetailing the activities of the informal and formal sectors.

The process of e-waste management includes several stages to maintain the sustainable lifecycle of electrical and electronic equipment. These equipment, are to be managed sustainably to reduce the usage of fresh materials in new products by recycling, expanding the life of products by refurbishing, etc. In addition, the recycling of e-waste involves steps such as collection, reuse and refurbishing, shredding, sorting, separation,

and recycling. The collection and transportation represent pivotal phases in the recycling process, encompassing the handling of e-waste as well. Following collection, the reusable electrical and electronic equipment are sent for refurbishing or reuse, if not these are recycled at the recycling facilities. The e-waste recycling plant operates effectively as it processes the electronic scrap while retaining the properties of many precious metals and minerals. Proper implementation of these processes ensures safe and responsible handling of e-waste promoting circular economy. As mentioned above, the e-waste recycling process involves several formal as well as informal players at different stages of e-waste recycling such as refurbishing, dismantling, segregation, etc.

The analysis in the paper is grounded in field surveys conducted in Maharashtra and Karnataka, which were chosen for their high e-waste generation, industrial ecosystems, and green technology developments. The paper identifies supply chain challenges, proposes an incentive mechanism, and further provides actionable recommendations to bridge the gap between informal and formal sectors. A total of 24 interviews were undertaken in Karnataka, while 35 interviews were conducted in Maharashtra for the analysis of the two states. The collected e-wastes are being sent to three major hotspots in Delhi including Shastri Park, Mustafabad, and Seelampur. Apart from these locations, in Uttar Pradesh, there are also some of the hotspots for e-waste like Meerut, Hapur, and Moradabad. In Bangalore, Gori Palya is considered an informal hotspot for e-waste recycling. The findings from the various visits have indicated that although other higher-order recycling operations might be centered in the formal sector, the collection, segregation, and first dismantling of non-hazardous e-waste fractions is handled by the informal sector.

India's e-waste supply chain is a multifaceted ecosystem, encompassing various stages spanning from collection, transportation, dismantling, segregation, recycling, and recovery. A target-based Extended Producer Responsibility (EPR) has started

showing positive results in formalising e-waste collection and material recovery but still, due to the dominance of the informal sector, the formal sector is facing intense competition and a severe lack of input feedstock (e-waste). In India, the informal sector currently serves as the mainstay for recycling and resource recovery. However, due to limited economic capital and technological access, the methods employed often rely on rudimentary practices, resulting in low efficiency and wastage of valuable resources. Moreover, the extraction processes utilised are hazardous to both human health and the environment. The inadequate recycling capacity within the formal recycling sector coupled with the e-waste leakage towards the informal sector is defeating the objectives of the E-waste Management Rules, 2022.

To encourage investments, innovation, and growth within the recycling sector, the paper proposes a Production Linked Incentive (PLI) scheme tailored to e-waste recycling. The scheme is designed as an outcome-based mechanism that rewards registered, high-capacity recyclers that comply with environmental norms and achieve specified recovery targets for key metals such as copper, iron, aluminium, nickel, silver, gold, and palladium. Incentives are to be linked to verified tonnes of secondary material recovered, with progressively tighter recovery benchmarks over time, thereby complementing EPR rather than substituting it. On the informal side, the PLI framework is coupled with a dedicated Recycling Development Programme (RDP) that encourages the registration of informal collectors with State Pollution Control Boards (SPCBs), supports them with social and health benefits, and technological handholding, and links their high collection efficiency to compliant recyclers through organised collection centres and clusters within the State. Together, these design elements aim to create a circular domestic supply of secondary materials, secure a stable supply of critical raw materials for India's clean energy and industrial transitions, and gradually transform the informal e-waste sector into a safer, more productive, and more transparent part of India's recycling ecosystem.