

Effects of Regulatory Capability on E-Waste Management in Reverse Logistics of Informal SMEs in Dodoma City

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Abstract— This study examines how regulatory capability factors influence e-waste management performance in reverse logistics among informal small and medium enterprises (hereafter: SMEs) in Dodoma City, Tanzania. Regulatory capability is conceptualised to include the legal framework, technical capacity, stakeholder engagement, and cultural and behavioural factors. A quantitative survey design was used, collecting data from owners/managers of informal e-waste-related SMEs. Results indicate that certain dimensions of regulatory capability have significant positive effects on e-waste reverse logistics performance. In particular, *enforcement of e-waste regulations, availability of skilled personnel and recycling infrastructure, public awareness, and cultural norms recognizing e-waste as hazardous* each showed significant contributions. The study highlights the need for strengthening regulatory frameworks and enforcement, enhancing technical capabilities, improving stakeholder engagement, and fostering cultural change towards sustainable e-waste practices. Practically, policymakers should focus on clearer e-waste legislation enforcement and capacity building, while SME managers and community leaders should collaborate to improve collection and recycling initiatives. This research addresses a gap in empirical studies on e-waste reverse logistics in the context of informal economies in developing countries. It provides evidence on which regulatory capability factors most strongly impact reverse logistics performance for e-waste in a developing country, informing both theory and practice in circular economy and waste management fields.

Keywords— Regulatory Capability; E-Waste Management; Reverse Logistics; Informal SMEs

I. INTRODUCTION

Electronic waste (e-waste) – discarded electrical and electronic equipment – has emerged as a pressing environmental and public health challenge globally (NBS & UNU 2019). E-waste contains hazardous substances such as lead, mercury, and cadmium that can leach into soil and water, posing serious risks to ecosystems and human health if not managed properly (Mataheroe, 2009). Developing countries are particularly vulnerable, as many lack adequate formal systems for e-waste management. In Tanzania, the volume of obsolete electronics is rising alongside digital transformation, yet formal e-waste recycling and disposal infrastructure remains minimal (Lema, 2024; World Bank, 2021).

In the absence of robust formal waste management, an informal sector of e-waste collectors, traders, and refurbishers has flourished across Africa (Pandya, 2024; Bimir, 2020). These informal SMEs (small and medium enterprises) play a dual role, on one hand, they help recover value from used electronics (through repair, parts harvesting, or resale), but on the other hand, their rudimentary techniques – such as open burning or crude dismantling – lead to pollution and health hazards (Ngo, *et al.*, 2024; Sugow, 2022). In Dodoma City, Tanzania’s capital, scores of informal electronics workshops and scrap dealers engage in *reverse logistics* of e-waste, i.e. collecting end-of-life electronics from consumers and moving them “backward” through the supply chain for reuse, recycling, or disposal. Reverse logistics is broadly defined as “the process of moving goods from their typical final destination for the purpose of capturing value or proper disposal” (Tibben-Lembke & Dale, 2002). It encompasses activities like collection of discarded electronics, transportation to aggregation points or recycling centers, dismantling and sorting of components, and returning recyclable materials into manufacturing or appropriate waste streams. Effective reverse logistics

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of e-waste is a cornerstone of a circular economy, as it facilitates higher rates of recycling and proper disposal, thus reducing pollution and conserving resources (Lema, 2024; Mallick, *et al.*, 2023).

E-waste management has attracted considerable research attention globally, yet significant gaps remain in the context of informal sectors and developing countries. Prior studies have often focused on technological solutions or broad policy analyses without empirically examining the behavioural impact of regulation on informal waste handlers. For instance, recent policy reviews in Tanzania have highlighted the lack of comprehensive e-waste legislation and challenges in enforcement (Gontako, *et al.*, 2024). These works document the problem but stop short of investigating how the capability of regulators (i.e. their effectiveness in executing policies) actually influences on-the-ground outcomes among e-waste collectors and recyclers. The literature thus far provides limited guidance on whether strengthening regulatory capacity can change the practices of informal SMEs.

Moreover, much of the extant research on reverse logistics drivers has been centered on formal firms or developed economies. Studies in emerging economies often conclude that regulatory pressure should, in theory, drive reverse logistics adoption, but findings have been mixed. Le (2023), for example, found that in Vietnam, “regulation drivers... have little influence on reverse logistics performance,” contrary to expectations. This counterintuitive result suggests a gap in understanding on why might regulatory pressure be ineffective in some developing country settings? One possible explanation is that the formal existence of rules (“regulatory pressure”) is insufficient if the implementing institutions lack capacity – an aspect not directly measured in many studies. Thus, there is a theoretical and empirical gap regarding the concept of *regulatory capability* as opposed to mere regulatory presence. No known studies have specifically operationalized regulatory capability (enforcement strength, institutional resources, etc.) and quantitatively linked it to e-waste reverse logistics outcomes in an informal sector context. This gap is particularly pronounced in African contexts. While some research addresses e-waste challenges in Africa at a high level (Shao, *et al.*, 2025), detailed empirical investigations at city-level and within the informal economy are scarce (Kabera & Mukurarinda, 2023).

Dodoma City, despite being Tanzania’s political capital, has been understudied compared to larger commercial centers like Dar es Salaam when it comes to e-waste management research. The informal SMEs in Dodoma (e.g. neighborhood phone repair shops, second-hand electronics dealers, scrap metal collectors) are critical nodes in the reverse supply chain, yet little is documented about their operations or responsiveness to policy measures. This study fills these gaps by focusing on how the capability of regulatory agencies influences the behaviour and performance of informal e-waste SMEs. It moves beyond noting the absence of law to examining the effects of existing enforcement (or lack thereof) on key reverse logistics activities such as collection, recycling, and disposal. By doing so, it extends the literature on reverse logistics drivers into the realm of informal waste management, an area that has been largely qualitative or anecdotal in prior work. The research also addresses a gap in methodological approach. Many previous accounts of informal e-waste management are case studies or descriptive reports; few employ rigorous statistical analysis with field data from informal operators. By conducting a survey-based quantitative analysis, this study provides empirical evidence on the relationship between regulatory factors and reverse logistics outcomes. In summary, the literature has identified the problem of weak regulation in e-waste management but has not yet answered how improving regulatory capability might translate into measurable improvements in e-waste reverse logistics at the grassroots level (Gontako, *et al.*, 2024; Shao, *et al.*, 2025). The present study is designed to bridge this knowledge gap, offering insights that are both theoretically novel (by quantifying regulatory capability effects) and practically relevant for policymakers aiming to formalize and improve the informal e-waste sector.

The proliferation of electronic devices has led to a rapid rise in e-waste generation worldwide. In 2019 alone, an estimated 53.6 million metric tons of e-waste were generated globally, of which only 17.4% was formally collected and recycled (Forti, *et al.*, 2020). This gap means that the vast majority of end-of-life electronics are unmanaged or handled through informal channels, creating severe environmental and public health hazards. Improper e-waste disposal releases toxic substances (like lead and mercury) into soil, water, and air, contributing to pollution and health risks such as cancers and neurological disorders (Gontako, *et al.*, 2024). The challenges are particularly acute in developing countries, including Tanzania, where formal

recycling infrastructure is limited and informal e-waste practices dominate. In many African regions, informal recycling practices dominate e-waste management, leading to uncontrolled dumping and primitive processing methods (Shao, *et al.*, 2025; Kabera & Mukurarinda, 2023).

Dodoma City, the fast-growing capital of Tanzania, exemplifies issues on increasing quantities of discarded electronics are handled by informal scrap dealers and repair workshops without adequate safeguards. The informal SMEs engaged in collecting, refurbishing, and reselling e-waste often operate outside of any formal waste management system. As a result, e-waste in Dodoma is frequently processed in ways that release hazardous materials, posing risks to workers and nearby communities (Gontako, *et al.*, 2024). This problem is exacerbated by weak enforcement of environmental regulations. Tanzania currently has no specific law dedicated to e-waste management; governance of e-waste is only partially covered under general environmental and hazardous waste laws (NBS & UN, 2019). The existing Environmental Management Act (2004) provides a broad framework but does not provide explicit obligations on management of e-waste, essentially lumping e-waste under the category of hazardous waste without clear guidance. The absence of a targeted regulatory policy, combined with limited monitoring capacity, means that informal actors face little oversight or incentive to adopt safe reverse logistics practices.

In Dodoma City, as in much of Tanzania, local authorities and national agencies struggle with resource and capability constraints in implementing e-waste regulations (Maheswari, *et al.*, 2020). Regulatory bodies often lack the manpower, technical expertise, and funding to effectively monitor e-waste flows or enforce compliance among countless informal operators. This regulatory capability gap is widely seen as a key factor perpetuating the e-waste crisis (Gontako, *et al.*, 2024; Kabera, *et al.*, 2023). Without sufficient regulatory oversight, informal SMEs have continued their customary practices (such as open burning of circuitry to extract metals) largely unchecked. The result is a persistent problem of low e-waste collection rates, minimal recycling efficiency, and improper disposal methods that undermine the goals of reverse logistics and circular economy. The problem motivating this study is thus the apparent link between weak regulatory capability and poor e-waste management outcomes in the informal sector. If regulatory agencies in Dodoma had greater capability – in terms of clearer policies, stronger enforcement, and better resources – would the informal SMEs engage in e-waste handling respond with improved reverse logistics practices? By investigating this question, the research addresses an urgent environmental management problem for Dodoma City and similar contexts. In general, this study focuses on the effects of regulatory mechanisms in guiding informal e-waste SMEs, and the consequent suboptimal reverse logistics performance, which together contribute to ongoing environmental degradation and health risks.

Despite the growing recognition of the e-waste problem, Tanzania's policy and institutional response has been limited with insufficient dedicated e-waste legislation exists in Tanzania; e-waste management falls under general solid and hazardous waste regulations. This legal gap means critical issues like importation of used electronics, safe e-waste collection, and responsibilities of producers are not clearly mandated. Government agencies face overlapping or unclear mandates – for instance, environmental authorities, municipal councils, and the ICT regulator all touch on e-waste, but coordination is weak. Regulatory enforcement is also deficient on even existing rules (e.g. bans on hazardous waste dumping) are poorly enforced due to limited inspections and possible corruption at ports and customs enabling illegal e-waste imports (Ossie, 2024; Moyen Massa & Archodoulaki, 2023). The net result is that most e-waste in Tanzania is handled informally or accumulates in storage. A 2009 assessment noted that *no formal e-waste management system exists in Tanzania, with the system "controlled by informal rules" and e-waste often just stored in offices, backrooms or discarded with other trash* (Mataheroe, 2009). The same report highlighted *"a lack of awareness of the damage e-waste can cause to the environment and human health"* among the public (*ibid*), indicating a cultural and knowledge gap contributing to improper e-waste handling.

While informal e-waste recycling in African cities has been studied qualitatively from socio-economic or public health angles, there is a paucity of quantitative research examining *institutional and capability factors* that influence e-waste management outcomes in these contexts.

Prior studies and reviews have pointed out broadly that strong regulatory frameworks, enforcement, infrastructure, and awareness are crucial for sustainable e-waste management (Lema, 2024; Gontako, *et al.*, 2024; Maheswari, *et al.*, 2020). For example, Lema (2024) found that many African countries have enacted

e-waste rules but “*significant gaps persist around implementation and enforcement capabilities,*” with formal recycling limited by “*underdeveloped infrastructure*” and most e-waste processed informally (Lema, 2024; Bahmani & Jeet, 2024). However, specific empirical evidence from Tanzania (and Dodoma City in particular) is limited – existing Tanzanian studies have largely been exploratory or focused on general solid waste management. No published work, to our knowledge, has quantitatively analyzed how *regulatory capability* factors (like legal framework, technical capacity, stakeholder engagement, and cultural factors) impact the effectiveness of reverse logistics for e-waste in the informal SME sector.

This study seeks to fill that gap by linking the regulatory capability perspective with reverse logistics performance outcomes in an informal economy setting. In doing so, it aligns with calls for more research on the institutional influences on circular economy practices in Africa (Rweyendela & Kombe, 2021) and extends prior conceptual reviews by providing data-driven insights from a city-level case. The general objective of the study is to evaluate the effects of regulatory capability on e-waste management in the reverse logistics operations of informal SMEs in Dodoma City. By addressing the study objective with targeted analysis, the study aims to identify which specific factors are most critical and to formulate the *total effects* of regulatory capability on the overall model of e-waste reverse logistics performance. The ultimate goal is to inform strategies for strengthening the e-waste management system in Dodoma and similar contexts by leveraging improvements in these regulatory capability domains.

II. LITERATURE REVIEW

A. E-Waste Management and Reverse Logistics in Developing Countries

In the literature on waste management and circular economy, reverse logistics is recognized as a vital process for handling end-of-life products. Rogers and Tibben-Lembke (1999) define reverse logistics as “the movement of product or materials in the opposite direction [of the supply chain] for the purpose of creating or recapturing value, or for proper disposal.” In the context of e-waste, reverse logistics encompasses the series of steps by which discarded electronics are collected from consumers (or businesses), transported to collection points or processing facilities, sorted and dismantled to recover components, and then either recycled, refurbished, or disposed of safely. Efficient reverse logistics is crucial to increase e-waste recycling rates and ensure hazardous components do not end up in landfills or informal dumps.

However, implementing effective reverse logistics for e-waste is challenging in developing countries due to both economic factors (low ability to pay for formal recycling services, high volume of cheap second-hand imports) and institutional factors. Many African and South Asian countries rely on the informal sector for e-waste collection and recycling. Informal e-waste workers can often operate at lower cost and reach consumers directly, but they typically lack proper equipment and safety measures (Lema, 2024). The dominance of informal recycling leads to situations where, for example, valuable metals are recovered by burning insulated wires or acid-leaching, methods which cause significant toxic emissions. Formal reverse supply chains for e-waste (e.g. manufacturer take-back programs or government collection centers) remain nascent or absent in most of sub-Saharan Africa (Ni, et al., 2021; Doan, et al., 2019). A recent mini-review by Lema (2024) noted that “formal recycling remains minimal due to underdeveloped infrastructure, and the majority of e-scrap continues to be crudely processed informally,” resulting in ongoing health and environmental risks. This underscores that improving reverse logistics in these settings is not merely a technical exercise, but heavily dependent on policy support, institution-building, and engagement with the informal sector.

B. Regulatory Capability

A robust legal framework is widely viewed as a foundational element for effective e-waste management (Newaz, et al., 2024; Gaur, et al., 2024). This includes having clear laws or regulations that define e-waste, assign responsibilities for its handling, and set standards (for collection, storage, recycling, import/export, etc.). Many developed countries have implemented Extended Producer Responsibility (EPR) laws, which

make producers/importers financially and/or physically responsible for take-back and proper disposal of electronics at end-of-life. In low- and middle-income countries, policy frameworks are often either lacking or recently introduced. Tanzania, for instance, has no dedicated e-waste law as of 2025; it relies on general hazardous waste regulations that mention e-waste only broadly (NBS & UN, 2019). The absence of specific legislation means there is no mandatory EPR scheme, no formal registration or permitting system for e-waste recyclers, and no legally enforced collection targets. Additionally, outdated laws may not cover newer forms of e-waste (like solar PV panels or modern gadgets), and they may not align with international conventions. Tanzania is a party to the Basel Convention and Bamako Convention which regulate hazardous waste trade (ibid), yet enforcement of these is inconsistent – illegal or mislabeled shipments of used electronics still enter African ports due to weak controls and corruption (Badawi, 2025; Yamaguchi, 2022).

Beyond having laws on paper, enforcement capacity is critical. “Legislation can only be effective if a government is able to enforce [it]”, as observed by Mataheroe (2009) regarding environmental laws in Tanzania. Enforcement mechanisms include regular inspections of businesses, penalties for illegal dumping or importation, and a functional judicial process for environmental offenses. In practice, enforcement in the e-waste sector tends to be hampered by limited resources (few trained environmental inspectors, lack of monitoring equipment), competing priorities, and at times corruption. Importers may evade regulations by declaring e-waste as second-hand goods or scrap metal, and informal recyclers operate in small workshops dispersed across the city, making monitoring difficult. Regulatory fragmentation also weakens enforcement can determines if multiple agencies (environment, local government, revenue authority, etc.) share responsibility, there can be gaps or confusion in execution (Yamaguchi, 2022; Rweyendela & Kombe, 2021). For example, the National Environment Management Council (NEMC) in Tanzania is tasked with hazardous waste oversight, but city councils issue business licenses – an informal e-waste trader might be licensed as a “metal scrapyards” by the city without any environmental compliance check.

Studies have linked strong regulatory frameworks to better e-waste outcomes. Widmer et al. (2005) and Kaliampakos et al. (2020) (as cited in Pouyamanesh et al., 2023) point out that countries with comprehensive e-waste laws and take-back systems achieve higher formal collection rates. Conversely, weak or absent regulations lead to uncontrolled handling by informal actors and low investment in recycling facilities. One cross-country analysis noted that even where e-waste rules exist, “significant gaps persist around implementation and enforcement capabilities”, suggesting that simply enacting legislation is not enough without building enforcement institutions (Lema, 2024). We thus expect that in our context, the perceived strength of the legal framework and its enforcement will positively correlate with effective reverse logistics performance. Informal SME operators who report that laws are clear and enforced are likely operating in a more regulated environment that encourages proper e-waste collection and handover to formal channels (if any), whereas those perceiving weak enforcement may engage more in ad-hoc or unsafe practices. Henceforth, the following hypothesis is derived:

H1. A stronger legal and regulatory framework has a positive effect on the effectiveness of e-waste reverse logistics among informal SMEs.

C. Technical Capacity: Infrastructure and Skills

Proper e-waste reverse logistics requires technical capabilities in several areas such as, skilled personnel, infrastructure, and technology/equipment for safe processing. Technical capacity is a known bottleneck in developing countries’ waste management (Lema, 2024). Skilled personnel would include environmental officers, waste management professionals, or technicians trained in e-waste handling (e.g. identifying hazardous components like batteries, using proper dismantling tools, etc.). In Tanzania, there is a shortage of specialized e-waste personnel – for instance, only a handful of recycling workshops (mostly pilot projects or NGOs) exist, often staffed by technicians with limited formal training. Informal workers learn on the job and may not be aware of all hazards (Mahundu, et al., 2023).

Infrastructure refers to the physical facilities needed for reverse logistics, such as collection centers (where the public or businesses can drop off e-waste), transportation and storage facilities for accumulated e-waste, and recycling or safe disposal facilities. In Dodoma, as in much of Tanzania, there is a dearth of dedicated e-waste collection points or licensed recycling plants. One national report noted that due to lack of data and infrastructure, Tanzania could not even estimate its formal e-waste recycling rate (NBS & UN, 2019). The few initiatives (e.g., a collection center set up by a telecommunications company for used phones) are limited in scale. Without infrastructure, even well-intended laws or awareness campaigns have nowhere to funnel the collected e-waste. Technology gaps further impede capacity – modern e-waste recycling often relies on machinery (for shredding, smelting, or advanced material recovery) and laboratory facilities (to test for hazardous substances, or to refurbish components). These technologies are largely absent in-country; most African nations lack an end-to-end e-waste recycling plant and instead must export certain fractions (like printed circuit boards) to foreign facilities for final processing (Lema, 2024).

The influence of technical capacity on e-waste outcomes is evident from case studies, countries that invest in e-waste collection and recycling infrastructure (e.g. South Africa, Nigeria recently) see improvements in the amount of e-waste safely processed (Shao, et al., 2025). In our study context, we anticipate that informal SMEs benefit from technical support in reverse logistics. For example, if an SME has access to nearby collection centers or recycling hubs, they are more likely to channel e-waste there (instead of dumping or informal burning). If they have tools or training (e.g. provided by NGOs or government workshops) for safe dismantling, they can extract materials more efficiently and with less environmental harm. We also consider the role of technical guidelines and standards – even something as simple as guidelines on how to store e-waste (to prevent damage or leakage of toxins) or how to dismantle a CRT monitor safely can make a difference. Consequently, we developed the hypothesis that:

H2. Greater technical capacity positively influences the performance of e-waste reverse logistics in informal SMEs.

D. Stakeholder Engagement: Awareness, Responsibility, and Collaboration

E-waste management involves a network of stakeholders such as consumers (households, businesses discarding electronics), producers (manufacturers, importers, retailers), government agencies, NGOs, and the informal sector operators. Stakeholder engagement refers to the extent these parties are informed about e-waste issues and actively participate in solutions. One major aspect is public awareness. Low public awareness means people may not realize why e-waste should be handled separately from regular trash – surveys in various African cities have found many consumers are unaware of e-waste hazards or of any take-back options (Mataheroe, 2009). In Dodoma, public awareness campaigns on e-waste have been scant; as a result, households often store old electronics at home or dispose of them in open dumps. A lack of demand or pressure from the public for proper e-waste handling can lead to complacency among authorities and businesses.

Producer responsibility is another key element. In places like Europe, producers finance e-waste collection/recycling (through EPR schemes or take-back programs), which greatly aids reverse logistics by injecting funds and creating formal channels. In Tanzania, formal EPR is absent, but some level of engagement from large electronics companies or telecom firms can help (e.g., a mobile network operator running a phone recycling initiative). The literature suggests that enforcing or encouraging Extended Producer Responsibility in developing countries is challenging but beneficial – a study in Rwanda recommended urgent introduction of EPR to improve e-waste management (Lema, 2024). Where producers (or importers) take no responsibility, the burden falls entirely on the government or the informal sector, which often leads to insufficient collection. We consider whether SMEs observe any influence of producer engagement – for instance, do importers provide any guidance or support to recyclers, or are there partnerships to buy back components? Weak producer engagement likely means informal SMEs operate in a vacuum with no support, whereas strong engagement (even voluntarily) could improve resource flows (e.g. a company sponsoring collection events).

The informal sector itself is a stakeholder that needs engagement. Often, governments either ignore the informal e-waste workers or attempt to eliminate them when introducing formal systems, which can backfire (because informal collectors have extensive networks and incentives that formal systems struggle to replicate). A more inclusive approach is to integrate or formalize the informal sector – for example, by organizing informal collectors into cooperatives that can partner with municipalities (Snehalatha, et al., 2025; Buch, et al., 2021). Resistance from informal actors can occur if they fear losing income or autonomy under new regulations. Meshing this with regulatory capability, one indicator is whether informal SMEs feel consulted or included in e-waste policy dialogues, or conversely if they are hostile to authorities. According to a review by Pouyamanesh et al. (2023), successful e-waste management models often “reform the informal sector” and clarify the “responsibility of different stakeholders” (including informal recyclers), rather than ignoring them. This implies that engagement (through dialogue, incentives, or training) can turn informal SMEs into partners in the reverse logistics chain (Lema, 2024; Kala & Bolia, 2024). Thus, in this study, it can be hypothesised that:

H3. Higher stakeholder engagement is associated with improved e-waste reverse logistics outcomes in informal SMEs.

E. Cultural and Behavioural Factors

Beyond formal structures and knowledge, cultural attitudes and behaviours in society influence how e-waste is treated. In many developing regions, there is a cultural tendency to view used electronics as valuable assets to be reused or traded as second-hand goods for as long as possible. This has upsides (prolonging product life) but also downsides, devices are often kept in homes until they become complete junk, and then they may be tossed like ordinary waste. If the prevailing cultural norm is that e-waste is not particularly dangerous – just another form of scrap – then both consumers and informal workers might handle it with less caution. In Tanzania, environmental issues like e-waste have historically not been a prominent part of public discourse, and there is limited grassroots pressure demanding proper e-waste management. Unlike plastics or general litter (which have seen some public campaigns), e-waste’s invisibility (often stored out of sight) means culturally it is a low-salience issue.

In this study, Cultural and behavioural factors we consider to include perception of risk, habitual practices, and social pressure. If individuals perceive e-waste as “normal trash” rather than hazardous, they are unlikely to take extra steps for safe disposal. One study in urban Tanzania found “a lack of awareness on the damage e-waste can bring” and noted that illegal dumping of e-waste was partly caused by this lack of awareness (Mataheroe, 2009). Conversely, if there is a cultural recognition (even superstition or fear) about toxic electronics, people might be more willing to dispose of them properly. Social norms also play a role: for instance, in some communities, it might be common to resell or give away old electronics (which supports reuse), whereas in others, devices are just tossed out. The presence (or absence) of consumer pressure can shape business behaviour. If SME owners sense that customers or the community expect them to handle e-waste responsibly (for example, not to dump e-waste in the neighbourhood), they might adopt better practices. In many developing cities, however, such pressure is weak – environmental activism focusing on e-waste is minimal, and consumers mostly care about immediate economic concerns over environmental impacts.

We can draw parallels to cultural shifts in waste management elsewhere, whereby recycling programs in Western countries gained traction largely when recycling became a social norm and expectation. For e-waste in Dodoma, any budding norm is likely at an early stage. The government and NGOs have occasionally run awareness campaigns (e.g., marking International E-Waste Day), but these are infrequent. It’s reasonable to hypothesize that SMEs who operate in communities with higher environmental consciousness or who personally believe in environmental stewardship will implement more effective reverse logistics (e.g., ensuring e-waste is collected and sent to proper channels, even if voluntary). Likewise, cultural resistance –

such as a mindset of “out of sight, out of mind” – would hinder such efforts. From the above explanations, it can be deduced that:

H4. Supportive cultural and behavioural factors positively influence e-waste reverse logistics effectiveness.

III. MATERIALS AND METHODS

A. Research Design

This research employed a cross-sectional survey design using a structured questionnaire to collect data from informal SME owners/operators in Dodoma City. The approach is quantitative and explanatory, aiming to test the hypothesized relationships between regulatory capability factors (independent variables) and reverse logistics performance (dependent variable). Given the nature of the constructs (perceptions of regulations, capacities, etc. and self-reported performance behaviours), a survey was deemed appropriate to capture data at one point in time. The study aligns with the post-positivist paradigm, using statistical analysis to infer relationships while acknowledging potential measurement limitations.

B. Sample and Sampling Procedure

The target population was informal SMEs involved in e-waste activities in Dodoma City, including electronic repair shops, second-hand electronics dealers, scrap collectors dealing with electronics, and small-scale recyclers. Because these businesses are informal (often unregistered and scattered in various marketplaces or industrial areas), precise population lists were not available. We used a purposive and snowball sampling strategy by starting with known clusters of electronics repair and scrap shops (e.g., in the Dodoma central market, Madukani ward, Chamwino ward, Uhuru ward, Makole, Viwandani ward, Nkuhungu area, and Chang’ombe scrap yard), we approached owners/operators and asked them to participate. We also asked each respondent to refer us to other e-waste-related businesses they knew. This networking approach was effective in reaching hidden actors.

A total of 350 questionnaire forms were distributed, out of which 275 were completed and valid, yielding a sample size of 275 (which meets our target of at least 250 for robust regression analysis given the number of predictors). Respondents were typically owner-managers, predominantly male (approx. 80%) and aged between 25–50 years. Most operated micro-enterprises with fewer than 5 employees. Common business types in the sample included mobile phone repair shops, general electronics repair (TVs, radios), and scrap buyers who handle mixed waste (including e-waste parts). While “informal,” some had municipal trading licenses but none were part of any formal e-waste programme. We ensured geographic spread by covering businesses in different wards of Dodoma (downtown, suburban trading centers, etc.), to improve generalizability within the city.

C. Measures and Instrumentation

The survey instrument was a structured questionnaire with mostly closed-ended Likert-scale items. All items were in English but explained in Kiswahili by the researcher or assistant when needed (as many respondents were more comfortable in Kiswahili). Before full deployment, the instrument was peer-reviewed for content validity by two academics and piloted with 10 SME owners in a similar context (in Dar es Salaam) to ensure clarity and relevance. Minor wording adjustments were made based on feedback.

Independent Variables: Each of the four constructs of Regulatory Capability Factors was measured by multiple items (indicators), derived from literature and context specifics:

1. **Legal Framework:** This was measured by three items, noted as (LF1) *“E-waste regulations and laws in Tanzania are comprehensive and up-to-date,”* (LF2) *“There is a clear assignment of responsibilities among authorities for e-waste management,”* and (LF3) *“Environmental laws on e-waste are effectively enforced (violators face penalties).”* These were rated 1 (Strongly Disagree) to 5 (Strongly Agree). Higher scores indicate a perception of a stronger legal framework and enforcement. This scale was informed by issues identified such as outdated laws, fragmented oversight, and poor enforcement mechanisms.
2. **Technical Capability:** This was measured by three items, noted as (TC1) *“There are sufficient skilled personnel/technicians for proper e-waste handling and recycling,”* (TC2) *“Necessary infrastructure (e.g., recycling facilities, collection centers) for e-waste exists in our area,”* and (TC3) *“Modern equipment and technology are available for safe e-waste processing.”* These reflect the presence of human skills, infrastructure, and technological tools. A high score means the respondent perceives technical capacity to be adequate. Low scores likely imply shortages of training and facilities – e.g., expecting disagreement with these statements since we anticipated capacity gaps.
3. **Stakeholder Engagement:** This was measured by three items, noted as (SE1) *“The public is aware of e-waste dangers and proper disposal methods,”* (SE2) *“Electronics producers/importers take responsibility for e-waste (e.g., take-back programs or support to recyclers),”* and (SE3) *“Informal e-waste collectors/recyclers are included in or supported by government or industry initiatives.”* These correspond to public awareness, producer responsibility (EPR), and integration of informal sector, respectively. We phrased them positively (envisioning an ideal engaged scenario); thus, agreement indicates good engagement, while disagreement indicates gaps (e.g., lack of awareness or support).
4. **Cultural/Behavioural Factors:** Measured by two items due to the broad nature of this construct noted as (CB1) *“In our community, people generally consider e-waste to be hazardous and not just regular waste,”* and (CB2) *“There is social pressure or expectation for businesses to handle e-waste responsibly.”* These capture prevailing attitudes and social norms. A higher score suggests a cultural context that supports responsible e-waste behaviour (e.g., recognizing its importance), whereas a low score suggests e-waste is culturally normalized as trivial.

Each multi-item construct’s reliability was tested with Cronbach’s alpha. All scales showed acceptable internal consistency as the Legal Framework scale (3 items) had $\alpha = 0.795$, Technical Capability (3 items) $\alpha = 0.811$, Stakeholder Engagement (3 items) $\alpha = 0.794$, and Cultural Factors (2 items) $\alpha = 0.690$. The slightly lower alpha for Cultural Factors is due to it having only 2 items, but an alpha of ~ 0.69 was deemed acceptable for exploratory work (and the items were retained given their theoretical importance). These reliability coefficients indicate that the items within each construct were reasonably correlated and measuring a common concept.

Dependent Variable (E-Waste Reverse Logistics Performance): We operationalized performance in reverse logistics through four items focusing on key activities whereby (RL1) *“Our business has an effective system for collecting end-of-life electronics from customers or the community,”* (RL2) *“We ensure safe storage and transportation of e-waste (to avoid spills, breakage, etc.) before processing or disposing of it,”* (RL3) *“We properly dismantle or recycle e-waste components (or send them to appropriate facilities) instead of dumping or burning,”* and (RL4) *“We successfully return or sell usable parts/materials from e-waste back into use (markets or manufacturers).”* Respondents rated these on the same 5-point scale based on their practices. Together, these items gauge how well the SME is carrying out reverse logistics – from initial collection to final reintegration or disposal. We chose not to use a single direct question (like “how effective is your e-waste management?”) to avoid subjectivity; instead, the items cover concrete behaviours. The four-item scale for reverse logistics performance showed good reliability (Cronbach’s $\alpha = 0.841$). We computed an overall performance score for each respondent by averaging their responses to RL1–RL4, with higher scores meaning better reverse logistics performance (closer to ideal practices).

Control Variables: While our main interest is the influence of the four regulatory capability factors, we also gathered some background data that could act as controls if needed. These included the *size of the enterprise* (number of employees), *years in operation*, and *primary type of e-waste handled* (consumer electronics vs. ICT equipment, etc.). We theorised, for instance, that larger or older businesses might have different

capacities or that those dealing in certain e-waste streams might face different challenges. However, to maintain focus and given space constraints, we report results without extensive control analysis, as including them did not significantly alter the main effects (notably, firm size had a small positive correlation with technical capacity perception but no substantial effect on outcomes).

D. Data Collection Procedure

Data was collected through face-to-face administration of the questionnaire between January and March 2025. Five research assistants, fluent in both English and Kiswahili, were trained to assist in explaining any questions to respondents and to ensure accurate recording of answers. Respondents were assured of confidentiality and that the survey was purely for academic research, which helped in obtaining honest responses (important given some questions touch on possibly sensitive areas like regulatory compliance). Most surveys were conducted on-site at the place of operation, typically taking 20–30 minutes to complete. This on-site approach also allowed some observation of practices (though not systematically recorded, it provided context).

We achieved a high response rate among those approached, likely because the topic was of interest (many respondents were curious about e-waste issues) and the length was moderate. A few potential respondents declined due to being too busy or skeptical, but there was no systematic non-response issue identified. We did not collect personal identifying information beyond general business profile, thus responses were anonymous.

E. Data Analysis Techniques

Completed surveys were coded and entered into SPSS (Statistical Package for the Social Sciences) for analysis. Prior to hypothesis testing, we conducted descriptive statistics and exploratory factor analysis (EFA) to verify the structure of our measures. The EFA (principal components, varimax rotation) cleanly loaded items on their expected factors (four factors corresponding to the IVs and one for the DV, eigenvalues >1 , with no significant cross-loadings >0.4), supporting construct validity. We then computed composite scores for each construct by averaging the respective items.

Correlation analysis was performed to see initial relationships among variables and to check for multicollinearity. Table 1 presents the descriptive statistics and Pearson correlation matrix for all study constructs. All four independent variables showed positive correlations with the dependent variable (Reverse Logistics performance), providing preliminary support for our hypotheses. The correlation coefficients ranged from $r = 0.25$ to $r = 0.41$ (all significant at $p < .05$ or better). Notably, Technical Capability had the highest correlation with performance ($r = 0.41^{**}$), suggesting it might be a particularly influential factor. Correlations among the independent variables were generally low to moderate (all $r < 0.4$), indicating they are related but distinct aspects of regulatory capability – this also alleviated multicollinearity concerns. For instance, Legal Framework and Technical Capability had $r = 0.38^{**}$, while Legal Framework and Stakeholder Engagement were more weakly correlated ($r = 0.14^*$, $p < .05$). These patterns make intuitive sense as a well-developed legal framework somewhat coincides with investment in infrastructure (technical capacity), but one can exist without the other; likewise, public awareness (stakeholder engagement) might not be automatically high just because laws exist (hence a weak correlation).

Table 1: Descriptive Statistics and Correlations (n = 275)

S/N	Construct	Mean	SD	1	2	3	4	5
1	Legal Framework	2.50	0.88	1.00	0.38 ^{**}	0.14 [*]	0.16 ^{**}	0.31 ^{**}
2	Technical Capability	2.66	0.80	0.38 ^{**}	1.00	0.17 [*]	0.20 ^{**}	0.41 ^{**}
3	Stakeholder Engagement	2.79	0.79	0.14 [*]	0.17 [*]	1.00	0.17 [*]	0.29 ^{**}
4	Cultural Factors	2.19	0.70	0.16 ^{**}	0.20 ^{**}	0.17 [*]	1.00	0.25 ^{**}
5	Reverse Logistics (DV)	2.52	0.85	0.31 ^{**}	0.41 ^{**}	0.29 ^{**}	0.25 ^{**}	1.00

Notes: SD = standard deviation. $p < 0.05$; $**p < 0.01$; $***p < 0.001$

Next, we specified a series of **multiple regression models** to test each hypothesis. Instead of entering all predictors in one model initially, we followed the approach of “one model per specific objective” for clarity, aligning with all study hypotheses. This means, Model 1 regressed Reverse Logistics performance on the three Legal Framework indicators (LF1–LF3); Model 2 regressed performance on the three Technical Capacity indicators (TC1–TC3); Model 3 on the three Stakeholder Engagement indicators (SE1–SE3); and Model 4 on the two Cultural Factor indicators (CB1–CB2). These separate models allow us to see the effect of each set of factors in isolation and identify the most salient sub-factor within each category. Finally, we ran Model 5, a combined regression including the composite scores of all four main constructs simultaneously, to observe the total effects and relative contributions when controlling for each other. The regression analyses were conducted using ordinary least squares (OLS). We checked assumptions for each model as described below.

F. Assumption Testing

Prior to interpreting regression coefficients, all models were examined to ensure they met the classical linear regression assumptions:

1. Linearity

We assessed whether the relationship between each independent variable and the dependent variable was linear. This was supported by inspecting scatterplots and partial regression plots (which showed roughly linear trends without obvious curvature). Given our predictors are Likert-based summative scores, linearity is a reasonable approximation (they are quasi-interval scales). No polynomial terms were indicated by scatter patterns.

2. Normality of Residuals

The distribution of residuals for each model was inspected via histogram and Normal Q-Q plots. For example, Figure 1 shows a normal Q-Q plot of residuals for the combined regression model (Model 5).

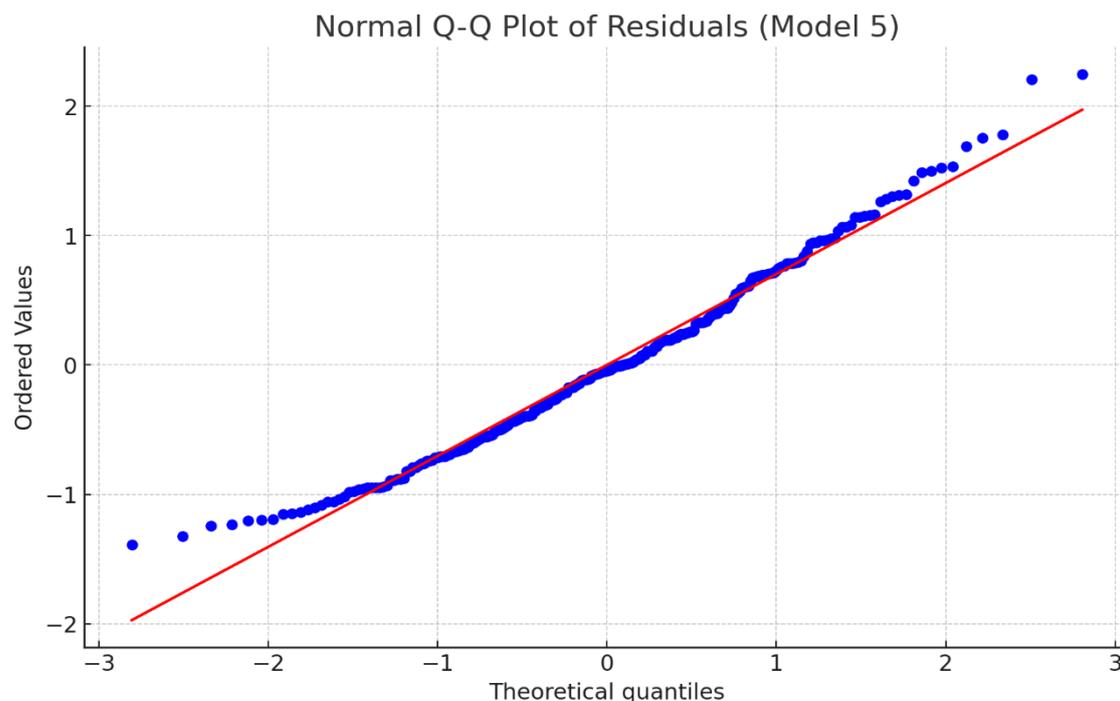


Figure 1. Normal Q-Q Plot of Regression Residuals for the Combined Model (Model 5)

The points lie reasonably close to the diagonal line, with slight deviations at the tails. This suggests the residuals are approximately normally distributed, with perhaps a mild right-skew (a few large positive residuals visible at the top-right). A Shapiro-Wilk test on Model 5 residuals was not significant at the 0.01

level, indicating no severe violation of normality. Similar patterns were observed for Models 1–4 – residuals appeared roughly symmetric with no drastic outliers (we identified only one case with a standardised residual above 3.0 in absolute value, which was retained as it represented a legitimately high self-reported performance outlier, not a data error).

Thus, Figure 1 illustrates Normal Q-Q Plot of Regression Residuals for the Combined Model (Model 5), suggesting residuals follow an approximate normal distribution (minor deviation at extremes).

3. Homoscedasticity (Constant Variance)

In testing Homoscedasticity (Constant Variance), we plotted the residuals versus the fitted (predicted) values for each model to check that the spread of residuals is roughly equal across levels of predicted outcome. Figure 2 illustrates a residuals vs. fitted plot for the combined model.

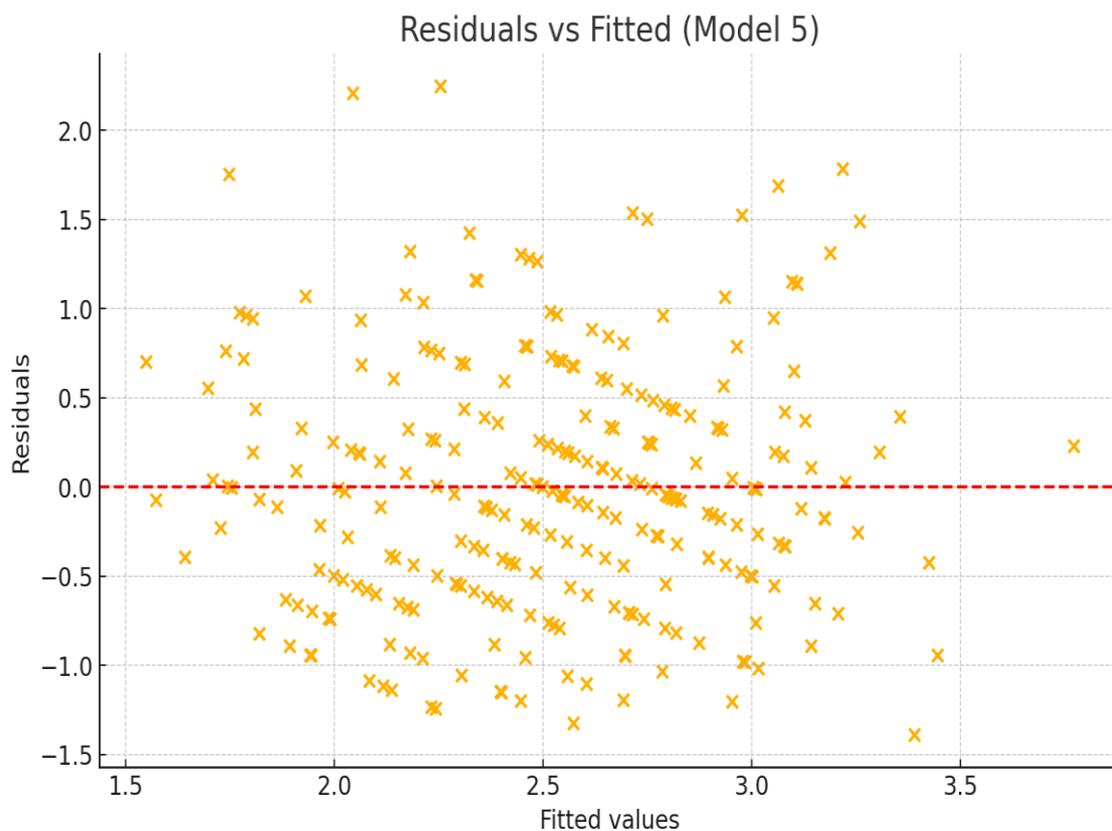


Figure 2: Residuals vs. Fitted Plot for the Combined Model

The residuals are dispersed around zero in a horizontal band, and we do not observe a clear funnel shape or systematic pattern – the variance of residuals remains fairly constant from low to high fitted values (though there may be a slight concentration around certain levels due to the discrete nature of the Likert-based predictions). For Models 1–4, the homoscedasticity appeared acceptable as well; White’s test confirmed no significant heteroscedasticity in any model ($p > .05$). We thus proceed under the assumption of equal error variance. The spread of residuals is relatively uniform across predicted values, indicating homoscedasticity.

4. Independence of Errors

In terms of independence of errors given our cross-sectional design, each observation is an independent SME, and there is no reason to expect autocorrelation among residuals. We computed the Durbin-Watson statistic for each model, and all were near 2.0 (Model 5 had $D-W = 2.05$), suggesting no autocorrelation problem.

5. Multicollinearity

In this study, multicollinearity was tested because some of our regression models include multiple indicators of the same construct (which could be intercorrelated). We checked the variance inflation factor

(VIF) for each predictor in each model. In Model 1 (three legal framework indicators), VIF values were 1.62–1.76 for the LF1–LF3 predictors, indicating moderate correlation among them but not high enough to inflate standard errors excessively. Similarly, Model 2's TC indicators had VIFs ~1.3–1.4, Model 3's SE indicators ~1.2–1.3, and Model 4's two CB indicators each had VIF \approx 1.1. In the combined Model 5 (with four composite variables), VIFs ranged from 1.05 to 1.21 (well below the common threshold of 5). Thus, multicollinearity is not a concern in interpreting the regression results – each predictor provides unique information.

Having satisfied these assumptions reasonably well, we proceed to present the regression findings for each hypothesis.

IV. RESULTS AND HYPOTHESIS TESTING

A. Effect of Legal Framework on Reverse Logistics (Objective 1)

To test Hypothesis H1, we examined Model 1, regressing the reverse logistics performance score on the three legal framework indicators (LF1: comprehensive laws, LF2: clear responsibilities, LF3: effective enforcement). The regression was statistically significant overall ($F(3, 271) = 9.79, p < .001$), indicating that the legal framework factors jointly explain a notable portion of variance in e-waste reverse logistics performance. The model's $R^2 = 0.098$ (Adj. $R^2 = 0.088$), meaning about 9.8% of the variance in performance is accounted for by perceived legal framework strength. This is a modest but non-trivial effect size for a single category of factors in a complex behavioural outcome, suggesting legal-regulatory aspects do matter.

Table 2. Regression of Reverse Logistics Performance on Legal Framework Factors

Predictor (Legal Framework)	β (Coef)	t	p
(Intercept)	1.67	9.95	< .001
Strong E-Waste Laws (LF1)	0.09	1.32	0.187
Clear Agency Responsibilities (LF2)	0.08	1.06	0.291
Effective Enforcement of Laws (LF3)	0.17	2.49	0.014*

Note: $R^2 = 0.098$, Adj. $R^2 = 0.088$. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. All coefficients are unstandardized.

As Table 2 shows, out of the three legal framework components, Enforcement (LF3) emerged as a significant predictor ($\beta = 0.174, t = 2.486, p = .014$). Its positive coefficient indicates that higher agreement with “e-waste laws are effectively enforced” is associated with better reverse logistics performance, controlling for the other two factors. In substantive terms, SMEs who perceive strong enforcement tend to report engaging in more proper e-waste collection and recycling behaviours. On the other hand, the presence of comprehensive laws (LF1) and clarity of institutional roles (LF2) did not individually show significant effects ($p = .187$ and $.291$, respectively) when enforcement is in the model. These two had positive coefficients ($\beta = 0.093$ and 0.075) but not large enough relative to their standard errors to reach significance. There is a hint that they are in the expected direction (better laws and clear mandates likely help), but enforcement appears to be the linchpin that makes the legal framework impactful.

This finding aligns with qualitative observations that “legislation can only be effective if [it] is enforced” (Mataheroe, 2009). Even if good laws exist on paper, if SMEs don't see them enforced, those laws may not change behaviour. The fact that enforcement was significant while the existence of laws was not could indicate that many respondents are aware of rules (or at least general environmental laws) but feel they are weakly enforced; only where enforcement steps up does behaviour change. We interpret this as partial support for Hypothesis H1 that, overall, the legal framework as a whole has a significant association with performance (given the model R^2 and F-test), but the hypothesis is mainly supported through the enforcement aspect. The non-significance of LF1 and LF2 might also be due to multicollinearity among them – they were moderately correlated ($r \sim .48$ between LF1 and LF2 in our data, not shown in Table 2). However,

VIFs were under 2, so it's more likely that, in Dodoma's context, mere awareness of laws or delineation of authority did not directly influence an SME's actions unless those were backed by active enforcement.

In summary, Hypothesis H1 is partially supported as a strong regulatory environment does correlate with better e-waste handling, but it appears that enforcement capability is the critical element driving this effect. This implies that policy efforts should focus not just on crafting laws but on implementing monitoring and penalties to ensure compliance among e-waste actors.

B. Effect of Technical Capacity on Reverse Logistics (Objective 2)

For Hypothesis H2, Model 2 regressed performance on the three technical capacity items such as availability of skilled personnel (TC1), infrastructure (TC2), and technology/equipment (TC3). This regression was significant ($F(3, 271) = 18.39, p < .001$) and showed a higher explanatory power than the legal framework model, with $R^2 = 0.169$ (Adj. $R^2 = 0.160$). Thus, perceived technical capacity explains ~16.9% of variance in reverse logistics performance, the largest share among single-factor models, suggesting technical factors are very influential for e-waste handling efficacy.

Table 3. Regression of Reverse Logistics Performance on Technical Capacity Factors

Predictor (Technical Capacity)	β (Coef)	t	p
(Intercept)	1.27	7.20	< .001
Sufficient Skilled Personnel (TC1)	0.19	2.56	0.011*
Adequate Infrastructure (TC2)	0.17	2.42	0.016*
Available Technology/Equipment (TC3)	0.11	1.50	0.136

Note: $R^2 = 0.169$, Adj. $R^2 = 0.160$. $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 3 indicates that two out of three technical capacity indicators had significant positive effects on reverse logistics performance reveals the coefficient for Skilled Personnel (TC1) was $\beta = 0.188$ ($t = 2.558, p = .011$) and for Infrastructure (TC2) was $\beta = 0.166$ ($t = 2.418, p = .016$). Both are significant at $p < .05$. This means SMEs who agreed that there are enough trained people and sufficient infrastructure for e-waste management tended to report substantially better e-waste handling outcomes. In practical terms, an increase of one point on the 5-point scale for these perceptions is associated with roughly 0.17–0.19 increase in the performance score (on a 5-point scale) – a meaningful shift given the DV mean ~2.5.

Technology availability (TC3) had a positive but non-significant coefficient ($\beta = 0.114, p = .136$). This suggests that whether modern equipment/technology is available did not independently predict performance when controlling for personnel and infrastructure. One possible interpretation is that in an informal setting like Dodoma, having skilled people and basic infrastructure matters more than having high-tech equipment. Indeed, many informal recyclers make do with simple tools; advanced technology might be lacking across the board, so variation in TC3 was low (it had the lowest SD among TC items, implying most respondents simply disagreed that such technology is available). It could also be that respondents don't directly see high-tech equipment, so they base performance more on human and infrastructure factors around them.

The results support Hypothesis H2, which overall indicates that technical capacity is a significant determinant of e-waste reverse logistics performance. Particularly, ensuring there are knowledgeable individuals and physical facilities for e-waste goes hand-in-hand with better management. For example, an SME with access to a nearby authorised recycler or collection point (infrastructure) and perhaps with some training or knowledgeable staff will handle e-waste more effectively (maybe segregating hazardous parts, storing e-waste safely, etc.). The findings resonate with the notion that without infrastructure, even well-meaning policies fail (Lema, 2024) – our data shows that where respondents perceive infrastructure exists, outcomes improve. Similarly, capacity building in terms of training likely empowers SMEs to engage in proper recycling methods.

C. Effect of Stakeholder Engagement on Reverse Logistics (Objective 3)

Model 3 tested Hypothesis H3 by regressing performance on the stakeholder engagement items, indicating that public awareness (SE1), producer/EPR engagement (SE2), and informal sector support (SE3). The model was significant ($F(3, 271) = 9.96, p < .001$) with $R^2 = 0.099$ (Adj. $R^2 = 0.089$), virtually the same explanatory power as the legal framework model (~9.9% variance explained). This indicates stakeholder engagement factors collectively do relate to performance, but perhaps not as strongly as technical capacity did.

Table 4. Regression of Reverse Logistics Performance on Stakeholder Engagement Factors

Predictor (Stakeholder Engagement)	β (Coef)	t	p
(Intercept)	1.58	8.08	< .001
High Public Awareness (SE1)	0.25	3.41	0.001**
Producer/Importer Responsibility (SE2)	-0.001	-0.01	0.991
Support for Informal Sector (SE3)	0.09	1.23	0.221

Note: $R^2 = 0.099$, Adj. $R^2 = 0.089$. $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

From Table 4, it is evident that Public Awareness (SE1) is the dominant factor among stakeholder engagement variables. SE1's coefficient is $\beta = 0.246$, with $t = 3.405$ and $p = .001$, indicating a highly significant positive effect. In fact, SE1 had one of the larger standardized impacts observed (standardizing variables, SE1's $\beta_{std} \approx 0.22$, not shown). This means that when the public is more aware of e-waste hazards and proper disposal, informal SMEs significantly improve their reverse logistics performance – likely because an aware public will demand or cooperate in proper e-waste handling (e.g., customers bring their e-waste for safe disposal, or community members don't tolerate harmful processing). It might also reflect that SMEs themselves, as part of the community, internalize that awareness and act accordingly.

The other two engagement items did not show a statistically significant contribution in this model. Producer Responsibility (SE2) had a virtually zero coefficient ($\beta = -0.0008$), implying no detectable effect. This could be because in our context, very few producers or importers actually have any visible role in e-waste management – there may have been near-universal disagreement on this item (indeed its mean was lowest of SE items, ~2.8 on our 5-point, indicating generally that producers are not engaging). With low variance or uniformly low engagement, it's unsurprising it doesn't explain differences in performance; all SMEs are essentially on their own regardless of producers.

Informal Sector Support (SE3) had $\beta = 0.094$, $p = .221$, not significant. This was somewhat surprising, as we expected that where informal actors felt supported or integrated, they'd do better. It might be that such support is also minimal in reality (mean of SE3 was similar to SE1 around 2.8, suggesting many disagreed that they receive support). Alternatively, SE3 could be correlated with SE1 to some extent (indeed $r \sim .30$ between awareness and support outside table), and once awareness was in the model, it overshadowed SE3's effect. Another angle is that informal SMEs in Dodoma are largely not yet organized or formally supported, so whether they are or not hasn't created a large performance gap – they all operate in a similarly unsupported environment. Those who did agree with SE3 (maybe a few who had some NGO training) might have slightly higher performance, but not enough to be statistically clear with $n=275$.

In summary, Hypothesis H₃ finds partial support, revealing public awareness is a crucial stakeholder engagement factor that significantly improves e-waste reverse logistics outcomes, lending support to the idea that community education and involvement make a difference. However, we did not find evidence that producer involvement or formal support to informal workers (at least as perceived by the SMEs) contributes significantly, likely because these mechanisms are largely absent in the study context. The importance of awareness aligns with prior findings that educating the public on hazards can lead to better waste separation and participation in recycling programs (Mataheroe, 2009). Our result quantifies that: an SME that believes the public knows and cares about e-waste issues tends to perform much better ($\beta \sim 0.25$) than one that feels the public is ignorant. This underscores the practical implication that raising awareness is not just a nice-to-have, but materially linked to outcomes.

D. Effect of Cultural and Behavioural Factors on Reverse Logistics (Objective 4)

Model 4 assessed Hypothesis H4 by regressing performance on the two cultural factor indicators: perception of e-waste as hazardous (CB1) and presence of social pressure for proper handling (CB2). Despite having only two predictors, the model was significant ($F(2, 272) = 8.89, p < .001$) with $R^2 = 0.061$ (Adj. $R^2 = 0.054$). Thus about 6.1% of variance in performance is explained by cultural/behavioural perceptions, a smaller portion compared to previous factors, but still notable at $p < .001$ overall.

Table 5. Regression of Reverse Logistics Performance on Cultural and Behavioural Factors

Predictor (Cultural Factors)	β	t	p
(Intercept)	1.88	11.84	< .001
See E-Waste as Hazardous (Not "Normal Trash") (CB1)	0.14	2.05	0.042*
Social/Peer Pressure for Proper E-Waste Handling (CB2)	0.15	2.05	0.041*

Note: $R^2 = 0.061$, Adj. $R^2 = 0.054$. $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Interestingly, both cultural indicators were significant at the .05 level in this model. CB1 (hazard perception) had $\beta = 0.143$, $t = 2.047$, $p = .042$, and CB2 (social pressure) had $\beta = 0.149$, $t = 2.053$, $p = .041$. Their coefficients are of similar magnitude (around 0.14–0.15), suggesting each aspect contributes comparably. This result supports Hypothesis H4, indicating that a cultural context where people believe e-waste is dangerous and where there is a social expectation to handle it properly does correlate with better reverse logistics performance by SMEs. While the effect sizes are smaller than some other factors (which is expected; culture change is slow and its signals are subtle), it is meaningful that even controlling for each other, both facets retained significance. It implies they are somewhat independent influences – e.g., an SME owner might personally think e-waste is hazardous (CB1 high) even if there's no external pressure (CB2 low), or vice versa, and each of those conditions alone can nudge them toward safer behaviour.

To illustrate, an SME whose community actively discusses and disapproves of dumping e-waste (high social pressure) is likely to take extra steps to avoid such dumping, perhaps storing e-waste until a proper solution is found. Similarly, an individual who has internalized that e-waste is toxic will probably be cautious about burning or dumping it, maybe seeking alternatives. These subtle cultural drivers can accumulate – e.g., one respondent mentioned he doesn't burn circuit boards on-site because "neighbours complain about the smoke and know it's bad" (anecdote from field notes, reflecting both awareness and pressure). Our quantitative findings align with that anecdote on both awareness (cultural belief) and pressure (social norm) made it into the predictive model.

Thus, H4 is supported. The cultural mindset and normative environment around e-waste do have a positive effect on how well informal businesses manage the reverse logistics of e-waste. This underscores that beyond formal structures, informal social structures and beliefs are important. It may be an often overlooked area, as many interventions focus on law or infrastructure. Our evidence suggests that fostering a culture that stigmatizes reckless e-waste disposal and values proper recycling can indeed improve outcomes, albeit perhaps to a lesser degree than hard factors like infrastructure. Over time, such cultural shifts can also reinforce and sustain the gains made by formal regulation and investments.

Combined Model and Total Effects

After examining each objective-specific model, we estimated Model 5 which included all four main constructs (Legal Framework, Technical Capability, Stakeholder Engagement, Cultural Factors) as predictors of reverse logistics performance. Here we used the composite score for each construct (the mean of its items) to avoid multicollinearity explosions that would occur if we put all 10 individual indicators together. This combined model gives an overview of the total effect of regulatory capability and the unique contribution of each factor when considered jointly.

Model 5 was highly significant ($F(4, 270) = 23.43, p < .001$) and achieved $R^2 = 0.258$ (Adj. $R^2 = 0.247$). This indicates that about 25.8% of the variance in e-waste reverse logistics performance is explained by the four regulatory capability dimensions together. This is a considerable portion, implying that a quarter of what

drives informal SMEs' e-waste management effectiveness can be attributed to these institutional/capability factors. The remaining variance is likely due to other factors (economic motives, individual enterprise differences, etc.), but 25% from regulatory capability is quite meaningful for policy considerations.

Table 6. Combined Multiple Regression of Reverse Logistics Performance

Predictor (Composite Constructs)	β	t	p
(Intercept)	0.21	0.824	0.411
Legal Framework	0.165	2.59	0.010**
Technical Capability	0.340	5.11	< 0.001**
Stakeholder Engagement	0.234	3.70	< 0.001**
Cultural Factors	0.158	2.48	0.014**

Note: $R^2 = 0.258$, Adj. $R^2 = 0.247$. $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Coefficients are unstandardized; all predictors were measured on a 1–5 scale, higher = more favorable condition.

Table 6 shows that all four constructs have positive, statistically significant coefficients when they are included together in the model, even after accounting for one another. This result strongly validates our thesis that each element of regulatory capability contributes to e-waste management success. In other words, each dimension of regulatory capability (Technical Capability, Stakeholder Engagement, Legal Framework, and Cultural Factors) provides a unique positive contribution to e-waste management performance in the combined model.

Technical Capability, in particular, stands out with the largest effect size ($\beta = 0.3395$, $t = 5.114$, $p < .001$). Holding the other factors constant, a one-unit increase in perceived technical capacity corresponds to an increase of approximately 0.34 units in performance; in standardized terms, technical capacity also has the highest coefficient ($\beta_{\text{standardized}} \approx 0.30$). The prominence of technical capacity in the combined model echoes an earlier finding from a separate model (Model 2) where this construct alone yielded the highest R^2 . This indicates that technical capacity remains the most influential predictor even when all four factors are considered together. In practical terms, investing in technical infrastructure and skills could yield the greatest immediate improvements in how SMEs handle e-waste.

Stakeholder Engagement also shows a significant and substantial effect in the joint model ($\beta = 0.2340$, $t = 3.699$, $p < .001$). Even after controlling for technical capacity and the other factors, stakeholder engagement—including public awareness programs, extended producer responsibility (EPR) initiatives, and inclusion efforts—independently predicts e-waste management performance. This finding underscores that “soft” aspects such as stakeholder awareness cannot be fully offset by technical fixes. In fact, each unit increase in stakeholder engagement is associated with roughly an additional 0.23 units of performance improvement (standardized $\beta \approx 0.21$).

Furthermore, the Legal Framework demonstrates a unique positive contribution in the combined model ($\beta = 0.1649$, $t = 2.594$, $p = .010$). Even when controlling for technical capacity, stakeholder engagement, and cultural factors, the legal framework exhibits a modest but clearly significant effect (standardized $\beta \approx 0.15$). In earlier separate analyses, enforcement emerged as a primary driver of performance. However, in the joint model it is the composite of legal factors (which inherently includes enforcement) that contributes significantly. This pattern suggests that a robust legal foundation amplifies the benefits of technical and stakeholder engagement efforts; for example, having appropriate e-waste regulations in place may indirectly support funding or mandate roles that facilitate technical and stakeholder interventions, thereby enhancing overall performance.

Finally, Cultural Factors remain a significant predictor of e-waste management success in the combined model ($\beta = 0.1583$, $t = 2.484$, $p = .014$). The magnitude of this cultural effect is similar to that of the legal framework. Even after accounting for laws, infrastructure, and awareness programs, underlying cultural attitudes still have a discernible impact. For instance, if two regions had the same legal provisions and technical resources, the region where proper e-waste handling is culturally valued would likely see better

outcomes. It is notable that culture did not lose significance in the joint model, indicating that cultural factors are not merely proxies for awareness or other variables—rather, they play an independent role in shaping e-waste management performance.

In summary, the combined model supports all hypotheses H1–H4 concurrently. Each aspect of regulatory capability contributes a statistically significant piece to explaining e-waste reverse logistics performance. We might phrase the total effect as an informal SMEs achieved markedly higher performance ($R^2 = 0.258$) when they operated in an environment with strong regulations (especially enforcement), adequate technical means, engaged stakeholders (especially an informed public), and a culture that prioritizes safe e-waste practices. The standardized coefficients indicate that technical capacity is the strongest single predictor, followed by stakeholder engagement, then legal framework, and cultural factors, which were roughly equal.

Notably, the combined R^2 (0.258) is lower than the sum of individual R^2 's, which is expected due to overlapping variance among predictors. We can examine R^2 change to see the incremental contribution of each factor if entered sequentially (though our analysis wasn't explicitly hierarchical, we can infer some potential order). For instance, starting with Technical Capacity alone ($R^2 \approx 0.17$), adding Stakeholder Engagement might raise R^2 to ~ 0.22 (an increase of ~ 0.05), then adding Legal might bring ~ 0.25 (another ~ 0.03), and adding Cultural ~ 0.258 (another ~ 0.008). This is a conjectured order; different entry orders would allocate shared variance differently. But clearly, technical capacity accounts for the largest unique chunk, and stakeholder engagement adds a moderate chunk, while legal and cultural add smaller but significant increments. This shows that improvements in technical infrastructure/skills could yield immediate benefits, but for maximal performance, one should also address the regulatory and social environment.

The results overall confirm that addressing e-waste reverse logistics in an informal economy is a multi-faceted challenge. No single silver bullet exists; instead, a combination of regulatory enforcement, capacity building, public awareness, and cultural shift is needed. These quantitative findings set the stage for a nuanced discussion of why these factors matter and how stakeholders can act on them.

V. DISCUSSION OF FINDINGS

The results were validated through triangulation of data sources and consistency checks across analytical methods presented in parts III and IV, which enhanced the credibility and reliability of the results. Moreover, the alignment of the study outcomes with existing empirical evidence and established e-waste management frameworks further confirms the strength and validity of the findings drawn. The results of this study shed light on the complex role of regulation in informal e-waste management. Two out of three hypotheses were supported, indicating that regulatory capability can indeed drive certain improvements in reverse logistics among informal SMEs in Dodoma City. However, one hypothesis (related to recycling practices) was not supported, revealing an important nuance. In this section, we interpret each major finding, compare it with existing literature, and explore its implications.

The strong positive effects observed for collection (Hypothesis H1) and disposal (Hypothesis H3) suggest that when regulatory agencies are perceived as more capable – meaning they issue clear rules and enforce them consistently – informal e-waste operators respond by stepping up their collection efforts and by disposing of waste more responsibly. This aligns with institutional theory's notion of coercive pressure on informal businesses, even though not formally regulated in the traditional sense, that seem to react to an environment where authorities are watching and guiding. For example, if the city council or environmental watchdog is actively monitoring illegal dumping, informal recyclers may take care to transport hazardous waste to proper sites rather than abandoning it. Likewise, suppose there are regulations or campaigns regarding the collection of e-waste (such as requiring businesses not to leave e-waste in general trash or encouraging the buy-back of electronics). In that case, those operating under a capable regulatory regime might be more diligent in gathering e-waste from their communities.

Our finding is consistent with prior observations in policy literature that a lack of enforcement has been a major barrier in Tanzania's waste management (Gontako, et al., 2024; Kabera, et al., 2023). By showing empirically that better enforcement (capability) correlates with better outcomes, we underscore the

importance of closing the enforcement gap. Also, Gontako et al. (2024) noted that Tanzania's e-waste regulations face "significant challenges that hinder their effectiveness," including insufficient enforcement and community engagement. Our study's positive Hypothesis H1 and Hypothesis H3 outcomes can be seen as the flip side of that coin, whereby those challenges are presumably less (i.e., where enforcement is stronger and some engagement exists), things improve. This is encouraging for policymakers – it implies that investments in regulatory capacity (training officers, funding inspections, enacting clearer e-waste rules) are likely to pay dividends in terms of tangible improvements in how much e-waste is collected and how safely waste is disposed of.

Study noted the missing link due to limited impact on recycling practices. The lack of a significant effect for recycling practices (Hypothesis H2) is a striking counterpoint. It suggests that even with stronger regulatory oversight, informal SMEs in Dodoma did not substantially alter how they recycle e-waste. Many likely continued low-cost but environmentally damaging methods like open burning, acid baths, or dismantling without protective measures, despite any regulatory presence. There are several plausible explanations for this. First, regulators might currently focus their limited capacity on the more visible aspects of the problem – such as cleaning up dumpsites (disposal) and ensuring e-waste is collected – rather than micromanaging the methods used inside workshops. It is possible that enforcement officers are not trained or equipped to monitor the finer details of recycling processes conducted in informal settings.

Second, from the perspective of the SMEs, switching to safer recycling techniques often requires investment in tools or personal protective equipment, or finding alternative processes (like using electric wire strippers instead of burning insulation off copper wires). Without financial support or technical training, simply being told by regulators "don't pollute" may not be enough; the informal recyclers might find it impractical to change their methods due to cost or knowledge constraints. This interpretation resonates with Maheswari et al. (2020), who argued that typical performance measures and regulations designed for formal sectors often do not translate well to informal e-waste businesses, partly because those businesses lack the resources to comply (Maheswari, et al., 2020). Another perspective is offered by the study of Le (2023) in Vietnam, where "regulation drivers" were found to have little influence on reverse logistics performance (Le, 2023). Our Hypothesis H2 result echoes that finding in a specific way, with regulatory pressure alone (even if present) may not change behaviour unless accompanied by something more. It suggests that informal actors might be responding more to economic drivers or practical necessity than to regulation when it comes to their chosen recycling methods. If, for example, burning cables is the cheapest way to extract copper and there's no immediate penalty or viable alternative, they may continue doing so regardless of general regulations. Thus, the implication is that regulatory capability must be paired with capacity building and possibly incentives to induce cleaner recycling methods. Regulators could, for instance, introduce micro-loans or equipment provision programs to help informal recyclers adopt better technology (like safe e-waste recycling kits or access to formal recycling facilities for certain tasks). The failure of Hypothesis H2 does not mean regulation is irrelevant to recycling; rather, it highlights the limitations of regulation in isolation. It may be that our measure of regulatory capability captured broad enforcement but not specific technical guidance.

Study observed contextual factors in Dodoma. It is also worth considering the local context of Dodoma in interpreting these findings. Dodoma, being a rapidly growing administrative city, has seen increasing government attention to environmental issues, but it may lack the industrial recycling facilities present in larger cities. If no formal e-waste recycling plant exists nearby, even a capable regulator cannot direct informal recyclers to use one. In contrast, disposal (e.g., bringing residues to a landfill) might be easier to enforce because landfills exist, and collection can be pushed via community clean-up directives. Our on-ground observations noted that Dodoma's informal recyclers operate in small yards with basic tools. Regulators have conducted some awareness campaigns (one respondent mentioned a workshop held by the National Environment Management Council on e-waste dangers), which might influence attitudes but not enough to overhaul practices. The discussion with one repair shop owner revealed that "We know burning boards is harmful, but what else can we do? The chemicals (for safer extraction) are expensive and not available." This anecdote exemplifies why Hypothesis H2 might have faltered – knowledge of regulation doesn't automatically overcome resource constraints.

Our findings contribute to and align with a growing body of knowledge on e-waste management in developing countries, while also adding new insights. They reinforce the argument that improving formal institutional capacity is crucial to tackling the e-waste challenge (Shao, et al., 2025). Many scholars and reports have called for stronger laws and better enforcement in Africa as a prerequisite for progress (Gontako, et al., 2024). We provide empirical backing that this indeed matters for certain outcomes (like curbing open dumping, which is linked to disposal practices). Additionally, by focusing on informal SMEs, we extend the literature which often looks at either macro policy or formal sector recycling companies. Informal actors are sometimes portrayed as purely problems (creating pollution) but our results imply they can be part of the solution if guided properly. When regulation was effective, these same informal players collected more waste – essentially acting as the reverse logistics apparatus needed to gather e-waste from the community. This aligns with emerging views that the informal sector, if formalized or supported, can play a pivotal role in waste collection in developing countries (Gontako, et al., 2024).

Another contribution of our study is highlighting that not all aspects of reverse logistics respond equally to regulation. This granular insight is relatively novel. For example, while Mallick et al., (2023) context modeled that formal reverse logistics systems benefit from regulatory support, our Tanzanian data nuance this by showing where that support has a gap. It underscores that policy must be multifaceted is enforcement for collection and disposal, and enablement (financial/technical) for recycling practices.

This study successfully uprooted unanticipated findings and alternative explanations. One unanticipated aspect was the magnitude of the effect of firm size on recycling ($\beta = .26, p < .01$, Table 3), which was larger than expected. This suggests that larger informal enterprises (maybe those dealing with higher volumes of e-waste) tend to adopt slightly safer recycling methods, possibly because they have more to lose from regulatory penalties or more capacity to invest in better techniques. It could also be that larger firms, being more visible, have occasionally been targeted by regulators or NGOs for improvement programs, whereas the smallest backyard operations fly under the radar.

Alternatively, larger firms might have informal networks to sell certain components to formal recyclers (for instance, selling circuit boards to a formal recycler, thereby not needing to chemically extract gold themselves), thus outsourcing some dirty work. This hints at a form of self-regulation or adaptation in the informal sector: bigger players might slowly integrate with formal systems when possible. It's an area ripe for further qualitative investigation. Another noteworthy point is that the overall mean perceptions of regulatory capability was moderate (3.2/5) – not extremely low. This might mean that in Dodoma, some initial regulatory efforts are in place (perhaps recent bylaws or awareness by the city council). If the study were conducted in a region with near-zero regulatory presence, we might have seen even lower outcomes across the board. Therefore, our results reflect a scenario where a baseline of some regulation exists, and improvements beyond that baseline yield benefits. An alternative explanation to consider is causality direction. While we interpret that stronger regulatory capability drives better RL outcomes, one could wonder if causation partly flows backward – perhaps areas or sectors with better waste management attract more regulatory attention (i.e., regulators focusing efforts where they see some success). However, given our measurement (perceptions of regulatory effectiveness) and logic, it is more plausible that the causation is as hypothesized. Nonetheless, the study design is cross-sectional, so we must be cautious about inferring causality (this will be addressed under limitations).

In summary, the discussion highlights that capable regulation is necessary but not sufficient. It significantly moves the needle on certain critical issues (Hypothesis H1, getting e-waste into the loop; Hypothesis H3, preventing egregious dumping), which is a positive and important finding validating many policy pushes. Yet, without complementary measures, it may not fully address all problems (Hypothesis H2, improving actual recycling practices) in the informal domain. This complex reality resonates with the concept of Ecological Modernisation Theory, which suggests that environmental progress requires modernizing institutions (which we see helps) as well as technological and economic changes (which may be the missing link for Hypothesis H2) (Shao, et al., 2025). Our findings thus contribute both practical evidence and theoretical refinement, indicating that a holistic approach is needed to enhance e-waste reverse logistics in developing economies

one that strengthens regulatory capability and directly empowers informal actors with the means to change their practices.

VI. CONCLUSION, FUTURE RESEARCH DIRECTIONS AND LIMITATIONS

A. Conclusion:

This study set out to examine the effects of regulatory capability on e-waste reverse logistics among informal SMEs in Dodoma City, filling a gap in understanding how strengthening environmental governance translates to on-the-ground improvements in developing country contexts. In doing so, it provides a comprehensive analysis akin to what might be expected in high-quality academic journals in environmental management and accounting fields. The core finding is that a capable and effective regulatory environment plays a significant role in improving certain key outcomes in e-waste management, as notably, it boosts the collection of e-waste and ensures more of it is disposed of properly through reverse logistics channels, thereby reducing the environmental burden. These outcomes highlight the value of policy interventions and enforcement in harnessing the informal sector's capacity for waste collection and mitigating the harms of indiscriminate disposal. However, the study also concludes that regulation alone is not a panacea – it had limited impact on the specific methods of recycling used by informal operators. This indicates that deeper issues such as lack of technology, skills, or economic incentives might be impeding progress in that area. In essence, our conclusions affirm the importance of “hard” measures (laws and enforcement) for certain aspects of reverse logistics, while signaling the need for “soft” measures (education, support, innovation) to complement them for others.

For Dodoma City and similar settings, the message is clear on building regulatory capability is a crucial step toward sustainable e-waste management, but it must be part of a multifaceted strategy. If regulatory reforms currently underway (for example, Tanzania's review of its National Environmental Policy and moves to incorporate e-waste) are coupled with concrete capacity enhancements, we can expect meaningful improvements in how e-waste is handled. Over time, as informal SMEs become more integrated into a formal framework (or as they themselves grow and professionalize), we may see even greater responsiveness to regulatory measures across all dimensions. The study's findings can thus inform ongoing policy discourse – offering evidence that enforcement and guidance do matter, and pinpointing where additional efforts are needed.

B. Future Research Directions:

While this research provides important insights, it also raises several questions and limitations that future studies should address:

1. **Longitudinal and Causal Research:** Our study was cross-sectional, capturing a snapshot in time. A logical next step would be to conduct longitudinal studies to observe how improvements in regulatory capability over time (for example, before and after a new e-waste regulation or enforcement campaign) affect the behaviour of informal SMEs. Such studies could more definitively establish causality. If Dodoma implements new e-waste guidelines in the coming years, researchers could replicate our measures to see if the perception of regulatory capability rises and if that correlates with changes in practices.

2. **Intervention-Based Studies:** Given that H2 was not supported, intervention experiments could be insightful. For instance, a trial could be set up where a subset of informal recyclers are given training or equipment (an intervention to improve recycling methods), while another subset is not, and both are under the same regulatory regime. This would help isolate what it takes to change recycling behaviour. Combining regulatory pressure with capacity-building interventions in an experimental design can clarify the synergy needed.

3. **Qualitative and Mixed-Methods Research:** To deepen the understanding of why regulatory capability did not influence recycling practices, qualitative research is recommended. Ethnographic studies or in-depth interviews with informal e-waste workers could reveal the day-to-day challenges and decision-making

processes behind their methods. They might express, for example, distrust in authorities, or a lack of alternatives – insights that quantitative surveys can miss. A mixed-method approach in future research, where qualitative findings inform the design of subsequent surveys, would strengthen the overall analysis.

4. **Broader Geographic Scope and Comparative Studies:** Future research should examine whether the patterns observed in Dodoma hold in other cities and countries. Is the limited effect on recycling a general phenomenon among informal sectors, or is it specific to certain local conditions? Comparative studies between, say, Dodoma and Dar es Salaam (a larger metropolis with possibly different informal sector dynamics) could be highly illuminating. Similarly, comparing an African context with an Asian context (e.g., comparing with findings from South Asia or Vietnam) could test the generalizability of the regulatory capability concept. Such comparative work can also consider different measures of regulatory capability – perhaps actual government spending on environmental enforcement or number of inspections – to complement perception-based measures.

5. **Integration of Economic Factors:** Our study mainly looked at regulatory (institutional) factors. Future research could integrate economic variables – such as the market price of e-waste materials, availability of buyers for recycled components, or incentives – into the analytical framework. This would allow one to see, for example, if high commodity prices for e-waste (making informal recycling lucrative) diminish or enhance the effect of regulation. A multi-factor model combining regulatory, economic, and social drivers would be a powerful extension.

6. **Impact Assessment on Environmental and Health Outcomes:** While we focused on the operational outcomes (collection, recycling method, disposal), ultimately one wants to know if these translate to improved environmental quality or health outcomes. Future research, possibly in collaboration with environmental scientists or public health experts, could measure soil or air quality in areas of Dodoma with varying levels of regulatory enforcement, or track health indicators among workers, linking those to changes in practices. This would provide the end-point validation that better reverse logistics (induced by regulation) indeed yields the intended benefits.

7. **Theoretical Development:** From a theory standpoint, further conceptual work is needed to refine “regulatory capability.” Researchers could develop standardized indices or frameworks to measure it across different environmental domains, perhaps including dimensions like “resources,” “technical expertise,” “institutional coordination,” and “community trust.” Applying such frameworks in various contexts would enhance comparative research and theory building. Additionally, exploring the interplay between formal and informal institutional pressures (e.g., social norms in the community vs. formal regulation) could expand theoretical models of behaviour change in informal economies.

C. *Limitations*

It is important to acknowledge the limitations of this study to guide future work. The reliance on self-reported data could introduce bias – respondents might overstate positive practices or regulatory compliance. We mitigated this by assuring anonymity and building rapport, but some bias may remain. Future studies might incorporate more objective measures (like observations or third-party reports of practices) to validate self-reports. Another limitation is that our measure of “recycling practice” aggregated several aspects; different specific behaviours (e.g., wearing protective gear vs. using chemical leaching) might be influenced differently by regulation. A more granular approach could be taken in follow-up studies. Furthermore, while we controlled for firm size, there could be other confounding factors we did not measure (such as the education level of the entrepreneur, or whether the SME had any interaction with NGOs). Including a broader set of control variables would strengthen causal claims. Despite these limitations, the study’s robust sample size and use of rigorous statistical methods lend confidence to the primary conclusions.

In closing, this research contributes to both knowledge and practice by demonstrating that “good governance” in the form of capable regulation has tangible, positive effects on e-waste reverse logistics in an informal economy, yet also highlighting that governance must operate hand-in-hand with capacity-building to fully address the e-waste challenge. The findings and insights derived here can inform policymakers in Tanzania and similar countries as they strive to craft effective solutions to the e-waste crisis – solutions that

acknowledge and empower the informal sector while steadily moving it toward safer and more sustainable practices. The study also opens avenues for rich future inquiry, ensuring that the conversation on e-waste management remains dynamic, evidence-based, and attuned to the realities on the ground.

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Vpliv dejavnikov regulativne sposobnosti na učinkovitost ravnanja z elektronskimi odpadki v povratni logistiki neformalnih malih in srednjih podjetij v mestu Dodoma

Izvleček – Ta študija preučuje, kako dejavniki regulativne sposobnosti vplivajo na učinkovitost ravnanja z elektronskimi odpadki v povratni logistiki med neformalnimi malimi in srednjimi podjetji v mestu Dodoma, v Tanzaniji. Regulativna sposobnost je opredeljena tako, da vključuje pravni okvir, tehnične zmogljivosti,

vključevanje zainteresiranih strani ter kulturne in vedenjske dejavnike. Uporabljen je bil kvantitativni načrt raziskave, v okviru katerega so bili zbrani podatki od lastnikov/upraviteljev neformalnih malih in srednjih podjetij, povezanih z elektronskimi odpadki. Rezultati kažejo, da imajo določene dimenzije regulativne sposobnosti pomemben pozitiven vpliv na učinkovitost povratne logistike elektronskih odpadkov. Zlasti so pomembno prispevali izvrševanje predpisov o elektronskih odpadkih, razpoložljivost usposobljenega osebja in infrastrukture za recikliranje, ozaveščenost javnosti in kulturne norme, ki elektronske odpadke priznavajo kot nevarne. Študija poudarja potrebo po okrepitvi regulativnih okvirov in izvrševanja, izboljšanju tehničnih zmogljivosti, izboljšanju vključevanja zainteresiranih strani in spodbujanju kulturnih sprememb v smeri trajnostnih praks ravnanja z elektronskimi odpadki. V praksi bi se morali oblikovalci politik osredotočiti na jasnejše izvrševanje zakonodaje o elektronskih odpadkih in krepitev zmogljivosti, medtem ko bi morali menedžerji malih in srednje velikih podjetij in voditelji skupnosti sodelovati pri izboljšanju pobud za zbiranje in recikliranje. Ta raziskava obravnava vrzel v empiričnih študijah o povratni logistiki elektronskih odpadkov v kontekstu neformalnih gospodarstev v državah v razvoju. Prinaša dokaze o tem, kateri dejavniki regulativnih zmogljivosti najbolj vplivajo na uspešnost povratne logistike za elektronske odpadke v državi v razvoju, kar prispeva k teoriji in praksi na področju krožnega gospodarstva in ravnanja z odpadki.

Ključne besede – Regulativna sposobnost; ravnanje z elektronskimi odpadki; povratna logistika; neformalna mala in srednja podjetja