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The Role of Stakeholders in Reverse Supply Chain of EOL Mobile Phone Recycling for Developing Sustainable E-waste Management: Bangladesh Perspective

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Abstract: *Rapid growth of technology including disruptive innovations, and a high rate of obsolescence in the electronics industry have led to one of the fastest growing waste streams in the world which consist of end of life (EOL) electrical and electronic products. Bangladesh, one of the surging consumer markets of electrical and electronic products primarily due to its move from lower to lower middle income country is generating substantial amount of e-waste which may pose serious threats to the environment of this nation. The devastating nature of this threat is yet to be acknowledged adequately by the academic and practical research community despite the global insistence and appeal of managing the electronic waste (e-waste). Bangladesh is lagging behind to conduct impactful theory based academic research relating to the management of electronic waste. At this outset, this study examines the role of reverse supply chain members and their capabilities in end-of-life (EOL) mobile phones management which has a significant impact on the efficiency of processing recyclable electrical and electronic materials. The study uses a modified customer visit program based on 30 in-depth interview and current literature to identify supply chain members, their functions and issues affecting the reverse logistics flow of recyclable EOL mobile phones. The findings of the study demonstrate the logistics channel structure, stakeholders and functions, which may work as a foundation for identifying the issues affecting the efficiency and marketability of the existing reverse supply chain of EOL mobile phones.*

Keywords: *E-waste, End-of-life products, Mobile phones, Reverse supply chain, Bangladesh*

INTRODUCTION

By the end of 2017, global electronic waste is expected to grow 33%, which could "fill a line of 40-ton trucks end-to-end on a highway, spanning three quarters of the Equator"

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(Lewis, 2013). This staggering forecast is based on data compiled by Solving the E-Waste Problem (StEP) Initiative. StEP, a partnership of UN organizations, industry, governments, non-government and science organizations also predicts that United States and China will the biggest contributors of electronic waste generation for the next five years. The unprecedented growth of the generation of e-waste is not only contributed by developed countries but also by lower middle income countries like Bangladesh. Rapid globalization, urbanization and the resulting increased access to modern technology, increased purchasing power, proliferation of new product development and high obsolescence rate of electronic products are some of the many factors that generate a faster electronic waste stream from developing countries like Bangladesh (Alam and Bahauddin, 2015; Riyad et al., 2014; Yousuf and Reza, 2011; Ahmed 2010).

The government of Bangladesh and its noble vision of transforming the current Bangladesh into "Digital Bangladesh by 2021" is also contributing significantly although not intentionally towards the generation of larger amount of e-waste in Bangladesh. Bangladesh Bureau of Statistics (BBS) finds that more than 87 per cent households own at least one mobile phone, 94.1 percent households in urban areas and 85.2 percent in rural areas are connected with mobile network (Islam, 2016). These digital revolutions certainly improve communication, better living standard and literally bringing the entire world in one's mobile/ computer screen, however, all these advantages are accruing at the cost of toxic footprints.

Electronic waste or E-waste generally refers to the electronic equipment those reached at the end of their useful life. It is generally consisting of television, radio, mobile phone, computer, fax machine, photocopier, DVDs, CDs and many other household or business products containing electrical components with either power or battery supply. It is estimated that Bangladesh generates roughly 2.81 million metric tons of e-waste every year, which came out in a lone study conducted during 2009 (ESDO, 2010). As per that estimate the contribution of different sectors was like this: ship breaking yard (2.5 million metric tons/year), television (0.17million metric tons/year), computer (0.035million metric tons/year) and mobile phones (0.005 million metric tons/year) (ESDO, 2010). Of these e-wastes only 20 to 30 per cent are recycled (Ahmed, 2010) and the rest are disposed to open landfills, farming land and open bodies of water without understanding their harmful effects on human health and environment. Meanwhile, this is 2017 and the amount of e-waste that Bangladesh is generating now is presumed to be lot more in terms of number and in terms of the gravity of health and environmental hazards of these e-wastes (The Daily Star, 2017).

Bangladesh is yet to establish an efficient platform for e-waste recycling although the recycling activities are continuing by the informal sectors and mostly in very hazardous

environment (Ahmed, 2010). Bangladesh government has passed different acts and policies to protect the environment, such as- Environment Conservation Policy-1992, Environment Conservation Act-1995 and Environment Conservation Rules-1997, however, no specific law or ordinance is developed yet that can guide and manage the e-waste in Bangladesh (Rashid, 2016; Rahman, 2017). The absence of formalization through law and practice is elevating the detrimental impact of e-waste on environment and human health. This result in a growing concern and demand for designing a formal logistic framework and policy measure relating to e-waste recycling in a hazard-free environment.

In Bangladesh, e-waste management related issues are receiving attention in recent years in academia and media, however scant attempt has been made so far to explore this reverse supply chain. In particular, inclusive research need to be conducted to examine the key factors impacting the successful design and implementation of a reverse logistics system for end of life electronic products. Though it has been suggested that reverse logistic systems are similar to forward logistics systems (Murphy and Poist, 1989), most forward logistic systems remain poorly operational to handle the movement of product in a reverse channel (Stock and Lambert, 2001). Indeed, reverse logistic chain originates from many points to one whereas the distribution in forward logistic chain originates from one point to many points. Moreover, reverse logistics requires the management of different quality of products (recyclable items), involvement of different value adding activities (e.g. assembly, reworking and refurbishing), preservation of different cost structure in different stages of supply chain and complicated and less transparent negotiation throughout the reverse supply chain (Grabara, 2004).

It is evident in the academic literature that an established and empirically tested reverse logistics framework can provide guidelines to manage effective and efficient reverse logistic system and its subsequent policies (e.g. Stock,1992; Rogers and Tibben-Lembke, 1998; Carter and Ellram, 1998; Stock, 1998 and Dowlatshahi, 2000). However, the reliance on the frameworks developed in different foreign reverse logistic contexts may fail to adequately address the challenges and complexities that exist in the reverse logistics context of Bangladesh. For example, the application of a particular reverse logistics framework for e-waste management as developed in Japan, South Korea, Taiwan, which are the leading countries in e-waste policy management in Asia may not be equally applicable in Bangladesh. Japan formulated legislation to manage e-waste in 2000 and adopted an ERP (Enterprise Resource Planning) model where all stakeholders (e.g., consumers, retailers and manufacturers) of e-waste are compelled to share the burden of e-waste management costs (Rahman and Mahboob, 2015).

On the contrary, Bangladesh recycles a very insignificant portion of its e-waste and it is done through its informal sector in a hazardous environment. In addition, its stakeholders are unaware about the detrimental impact of e-waste on environment and health. The absence of government laid down legislation and enforcement of it is further aggravating the e-waste condition of Bangladesh. This background creates a strong need to identify a reverse logistics framework for Bangladesh that can tap the possible threats related to electronic waste to environment and society. The understanding of the degree of complexities that exists in the reverse logistics chains of end of life products in Bangladesh is also needed to provide directions to stakeholders and policy makers.

OBJECTIVES OF THE STUDY

The objective of the study is twofold: first, to identify the members/stakeholders of the reverse supply chain of end of life (EOL) mobile phones and second; to understand the challenges and complexities of the role played by the members of the reverse supply chain of EOL mobile phones in Bangladesh.

LITERATURE REVIEW

The global market of electronic products and equipment continues to grow exponentially as lifespan of those products becomes shorter. This lead to a new challenge to face by the world known as electronic waste management. Electronic waste (e-waste) in general refers to any white goods, consumer and business electronics, and information technology hardware those are in the end of their useful life. Puckett et al. (2002) define e-waste as “a broad and growing range of electronic devices ranging from large household devices such as refrigerators, air conditioners, cell phones, personal stereos, and consumer electronics to computers which have been discarded by their users”. These e-wastes have raised concerns all over the world because many components in the electronic products are toxic and do not biodegrade easily if at all. According to Allied Market Research (2015), global e-waste management market is expected to reach $49.4 billion by 2020. Shrinking life span and high obsolescence rate of electric and electronic products is also expected to be the most important drivers of accumulating e-waste by IT and telecommunication sector in the Asia pacific region. For example, in country like India, Bangladesh and Pakistan the migration of the rural population to smart phones as internet connectivity expands, availability of low cost mobile phones both in legal and grey channels is generating greater amount of e-waste in every year. Therefore, it is expected that a number of challenges such as high cost of recycling and e-waste management, low level of awareness in developing region and less number of e-waste collection zone around the world will also continue to persists and grow. On the other hand, it is also expected that there would be global scarcity of precious material. The

probability of the supply shortage of precious material can be reduced by converting the trash (e-waste) into cash, as for every one million cell phones that are recycled, 16 tons of copper, 350 kilos of silver, 34 kilos of gold and 15 kilos of palladium can be recovered (ITU, 2014).

Taking the speedy growth of e-waste around the world into account, many developed countries are exporting their unsafe e-waste in Asian countries include China, India, Pakistan, Malaysia, the Philippines, Singapore, Sri Lanka, Thailand and Vietnam (ILO, 2012). Through the export of 2nd hand electronic and electric products, these international flow of e-waste stream also creating an environmental and health problem for Bangladesh (Alam and Bahauddin, 2015). In addition to that, the visionary digital revolution and the resulting massive growth of electronic products are increasingly causing a disquieting growth of e-waste generation in Bangladesh.

The exponential growth of e-waste and its detrimental environmental, social and economic impact has drawn considerable attention among academics and professionals in Bangladesh. Their subsequent investigation thus covers a wide range of issues such as estimation of e-waste generation, identification of e-waste problems and its challenges, evaluation of existing e-waste management and related legislation and policy, future implications of e-waste, e-waste recycling, understanding the impact of illegal import on e-waste and role of informal sector in e-waste recycling. For example, a ESDO (2010) study find that more than 15 per cent child worker died due to the side effects faced during and after the e-waste recycling process and more than 83 per cent are exposed to toxics substances and become sick and live with long term illness. On the same note, Alam and Bahauddin (2015) identified a number of drawbacks of e-waste recycling like the difficulty in inventorization, unhealthy conditions of informal recycling, inadequate legislation and policy, poor awareness and reluctance on the part of the corporate to address the critical issues.

Among these problems, e-waste recycling management and the role of the informal sector in e-waste management attracted special research attention. Ahmed (2011) in his study on informal sector recycling practices in Bangladesh identified the e-waste hotspots in Dhaka and Chittagong, the member of e-waste recycling process and their level of awareness about the impact of e-waste on their health and environment. Riyad et al. (2014) specifically identified the number of people involved in the informal recycling job in Dhaka city and their economic gain. Their study reveal that, “around 1,20,000 urban poor from the informal sector have been found to be involved in the e-waste recycling trade chain in Dhaka city area where only children (under 10 year of age) accounted for approximately 50,000.

Though a considerable number of research has identified the major challenges and concern related to e-waste, few of them focused on interaction of these stakeholders such as public, consumers, producers, institutions, policy makers and legislators and their roles in e-waste management. Moreover, an efficient e-waste management process requires a clear understanding of the complex movement of second hand/refused electrical goods from its multiple origin to multiple destinations. At this outset, this is important to identify and understand the reverse logistics channel structure (both internal and external), memberships and functions, which may work as a foundation for identifying the issues affecting efficiency and sustainability of the existing e-waste management process.

The majority of the literature dealing with reverse logistics is both descriptive and anecdotal (knemeyer, et al. 2002; Carter and Ellram, 1998). However, exception to these, few research examined a more holistic view of reverse logistics. For example, Carter and Ellram (1998) claim that most literature on reverse logistics examines relatively narrow aspects such as recycling. On this backdrop, Carter and Ellram (1998) develop a model for identifying the external factors affecting reverse logistics. Dowlatshahi (2000), on the other hand focused on establishing internal strategic and operational issues that may require consideration in reverse logistic system. Taking a more holistic view toward reverse logistics, Stock (1992, 1998), Rogers and Tibben-Lembke (1998) provided a thorough discussion of the macro environment and task environment and its impact on the reverse logistics system of end of life products. In light of the prior research, knemeyer et al. (2002) proposed a conceptual model of reverse logistics for end of life products (including internal, external, macro and micro environmental factors) which provides additional clarity of a comprehensive and multifunctional view of reverse logistics system. This model of knemeyer et al. (2002) is adopted to explore the existing reverse supply chain and the related stakeholders of EOL mobile phones in Bangladesh (Figure 1).

The model is comprehensive in nature as it shows all the distinct types of tangible, external factors that affect the reverse logistics activities. The model also considers internal factors those primarily focus on strategic and operational factors relating to the implementation of a reverse logistic system. This conceptual model suggests that the external environment is comprised of four sectors: input, regulatory, output and competitive. Within these sectors, there is a need to examine five key internal strategic factors such as: strategic costs, overall quality, customer service, environmental concerns and legislative concerns. This study focuses on both internal and external factors and their influence on the role of stakeholders in the context of current EOL mobile phone recycling system in Bangladesh.

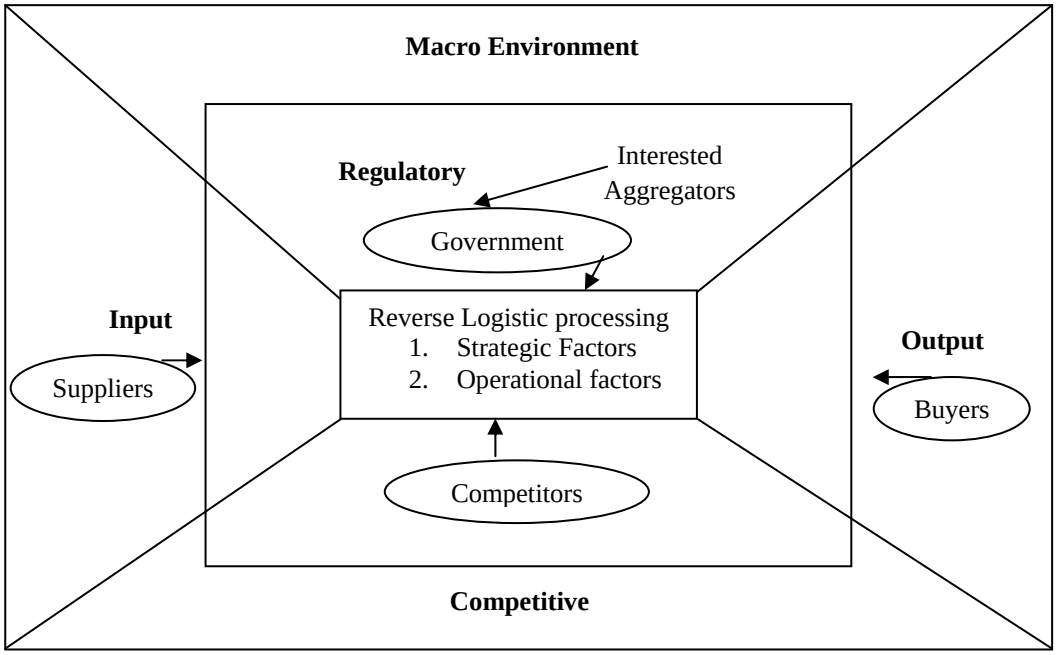

Figure 1: The Conceptual Framework

RESEARCH METHODOLOGY

A qualitative research approach is adopted to understand the role of stakeholders in the reverse supply chain of e-waste management in Bangladesh. The qualitative method that is used in this study is a modified version of the customer visit program. Qualitative interview is used to identify the factors that describe the existing reverse supply chain of EOL mobile phones in Bangladesh. The customer visit program as suggested by McQuarrie's (1991) allows researchers to collect information through interview in addition to the information that can be collected visually. According to McQuarrie (1991) the implementation of customer visitation program involves six-steps which are: setting objectives, select and recruit information providers, train and brief visit team, develop discussion guide, conduct interviews and analyse and report data.

The first step in the customer visit program is to set the research objective for the study. In the current research context, the research objective is to reveal the existing EOL mobile phones management emphasizing on its opportunities and challenges. The second step is to identify, select and recruit the stakeholders to be interviewed. In the present context, different stakeholders were interviewed and grouped into four major categories: input stakeholders, output stakeholders, regulatory stakeholders and competitive stakeholders. A total of 30 interviews were conducted with the above mentioned four stakeholder groups via personal visit. The average duration of the interview was one to two hours. The participant in those interviews were representing the stakeholders who are

directly involved in the electronic reverse supply chain process. A detail of interviews content in respect to different stakeholders is given in table 1. The third step was to make the interviewers acquainted (in this research context the interviews were conducted by the researchers) with the particulars of potential stakeholder visit. In other words, researcher identified the type of information needed and established the structure of the interview in order to obtain information. A visit/interview team was formed to conduct the interviews. The moderator guided the discussion, while the listeners were responsible for taking notes and recording the conversation. All the interviews were designed to identify potential sources of EOL mobile phones, potential markets, practices for recycling and re-manufacturing/dismantling.

Table 1: Interview Profile

<table>
<tr><th>Stakeholder</th><th>Interviewees</th><th>No. of Interview</th><th>Content of the Interview</th><th>Criteria for data interpretation</th></tr>
<tr><td>Input Sector</td><td>Tokai</td><td>4</td><td rowspan="3">- Collection points
- Type of collections
- Total cost of collections
- Sorting
- Other major issues in collections.</td><td rowspan="6">- Common words
- Context of the interview
- Internal consistency within and among interviews
- Frequency and extensiveness
- Intensity of comments
- Specificity of response.</td></tr>
<tr><td></td><td>Hawker</td><td>2</td></tr>
<tr><td></td><td>Buyers/Scrap Dealer</td><td rowspan="3">6</td></tr>
<tr><td>Output Sector</td><td>Buyers/Scrap dealer</td><td rowspan="3">- Scrap buying points
- Quality and cost of collection
- Sorting, dismantling, refurbishing and recycling
- Technical education on recycling - Recycling equipment</td></tr>
<tr><td></td><td>Wholesaler</td><td>6</td></tr>
<tr><td></td><td>Jobber</td><td>4</td></tr>
<tr><td>Competitive sector</td><td>Wholesaler and retailer of EOL mobile phones</td><td>6</td><td>- Data regarding supply and demand
- Price and quality
- Intensity of competition
- Market attractiveness for new entrants
- Market structure</td></tr>
<tr><td>Regulatory Sector</td><td>Dhaka City Corporation authority</td><td>2</td><td>- Available resources
- E-waste management issues
- Monitoring of e-waste management
- What is needed?</td></tr>
</table>

Note: Buyers/scarp dealer is performing both of the role of EOL mobile phone collectors and recycling. Tokais are individual who pick different types of waste from different places and Hawkers but those collections from Tokais and from household and commercial places.

This led us to the fourth step, which is the development of a discussion guide (that is shared with research team) with a formal set of unstructured questions for conducting the interview. At the fifth step the actual interviews were conducted. In order to explore the role of reverse supply chain of electronic waste, its opportunities and challenges the interviews covered a wide range of topics which includes but not limited to stakeholder's interest to be involved in electronic waste management process, their ability to act in the recycling process and their current activities and level of expertise. The stakeholders were also requested to provide suggestions on how to make this e-waste management process effective and efficient. To keep the interview structure consistent throughout the process, all of the interviews were conducted by the researchers. One researcher served as the moderator while the other served the role of a listener and note-taker. The research assistant also plays the role of an observer and note-taker. After completing the interview, the researchers conducted a debriefing session, which included analysis of interview notes and recording of results.

RESEARCH FINDINGS

The findings of the study are derived from qualitative data analysis that was collected primarily through in-depth interviews. The findings are categorized according to the conceptual framework and are presented under two broad sections: stakeholders and organisational considerations of EOL mobile phone recycling system.

Stakeholders of EOL mobile phone recycling

The stakeholders those are related to EOL mobile phones reverse supply chain system are categorized into four sectors: input, output, competitive and regulatory. These four groups are directly or indirectly involved in the process of collection, sorting, dismantling, refurbishment and recycling of EOL mobile phones. The schematic of the reverse supply chain of EOL mobile phones is presented in figure 2.

Input Sector

It is estimated that 63 million cell phones were imported to Bangladesh in the last 3 years through legal channel while in 2016 alone the figure stood at 31 million (Daily Star, 2017). The imports from grey channels cannot be estimated but presumed to be countless. Taking into account the number of legal and illegal cell phone imports and their users, this is one of the major sources of e-waste in Bangladesh right now. According to BTRC, 2015 more than 130 million out of the 160 million Bangladeshis use at least one Mobile phone (Bdnews24, 2015). It is estimated that on an average 30 percent phones become

useless in each year (BCS, 2015). During the interview with different users of mobile phones, it was found that, user usually dispose off their end-of-life mobile phones in different ways such as keep it as unused or put it in temporary storage, repair it and sells to others (online and offline), throwing it to the bin, sell it to hawkers by weight or give it to the child to play as toys which ultimately goes to bin or hawkers.

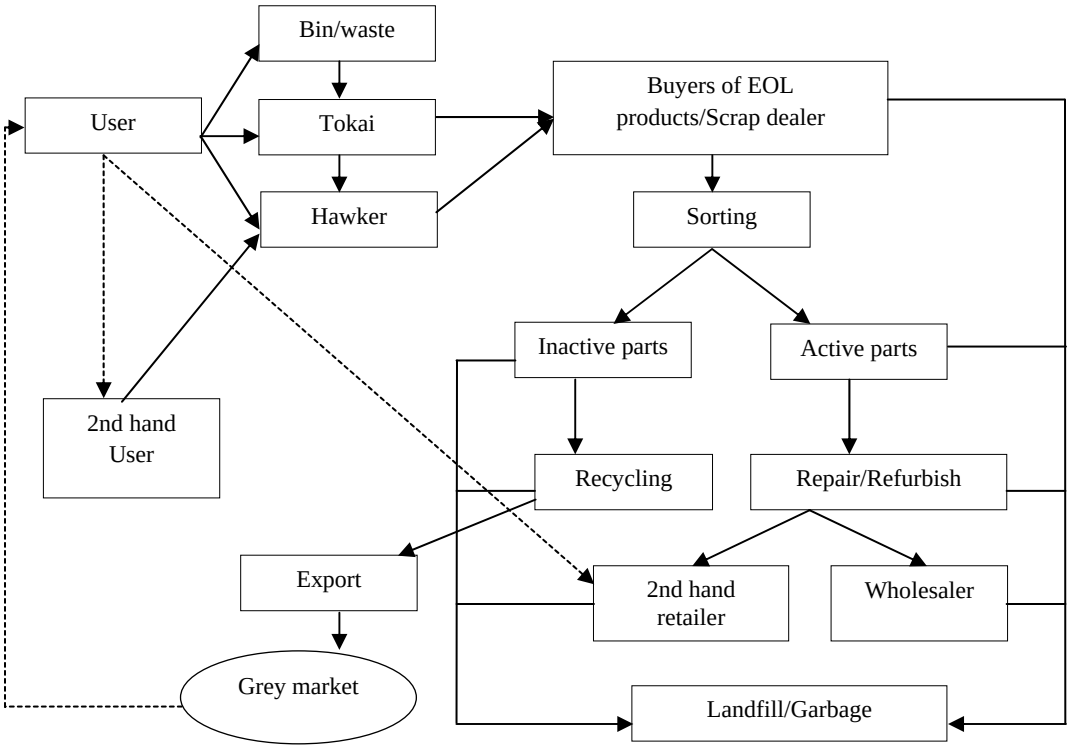

Figure 2: Schematic of reverse supply chain of EOL mobile phones

The study finds that 'Tokai' along with collecting other waste such as plastics, paper, bottle, tin, iron, polyethylene etc. also collects electronic waste from road-side bin, street, station, park, bank of rivers, municipality landfill and other places. Retailer's and company owned showrooms that sells mobile phones is also a major unit of end-of-life products collection. Since most of the mobile phones are offered with guaranties and warranties, faulty and replaced EOL mobile phones are collected from different customer service point.

It is apparent from the in-depth interviews that the supply of EOL mobile phones are continuous and increasing day by day, however, no specific data or the approximate estimation are available regarding the supply. One possible reason for this unavailability of information could be the existing disintegrated collection system of EOL mobile

phones. Supplies are coming from public (general consumers), private (distributors and retail shops of mobile phones) sources, but no authorities/bodies/associations of mobile phone distributors (both public and private) are monitoring the coordinated collections of these EOL mobile phones. However, literature suggest that the success of an efficient reverse supply chain for EOL products largely depends on sufficient volume of quality input materials (Stock, 1998; Knemeyer, et al. 2001).

Output Sector

A group of wholesaler/scrap dealers buy all types of EOL mobile phones including its parts from tokai, hawkers and small retailers at a price of BDT 20 to 40 per kg. A portion of EOL mobile phones also enter into the output sector through illegal chain such as theft. The major hotspots of these wholesaler groups are usually found in Nimtoli, Dholaipar, Gulistan, Dholaikhaal, Mohammadpur and Mirpur. The wholesalers then sort the EOL mobiles and parts into two categories- active (repairable) and inactive (damaged) with the help of local repairman. The repairman involves in the value addition process such as change of casing and batteries, repair the dial key/buttons, display and mouth speaker. The repairable phones or active parts are sold to the retailers (a small group of retailers who buy and sell second hand mobile phones) at a price ranging from BDT 30 to 200 per piece. The retailer usually combines the working parts of broken phones with the working parts of other used cell phones to make one ready-to-use mobile phone. The rebuilt phone is sent back to the market. There are some third parties also known as jobbers (a small group of wholesaler) whose task is only to collect the refurbishable mobile phones or active parts of mobile phones from wholesalers from different collection points such as Gulistan. These jobbers also sell those repairable mobile phones to the small retailers at a price of BDT 40 to 250/piece.

The inactive parts or phones those are not repairable or useable, are re-sorted into 4 categories- metal, plastics, glass and garbage. More specifically, phones are dismantled and sorted into different components such as batteries, printed circuit boards, handsets, chargers/accessories, plastics, metals and paper/cardboard packaging under the mentioned four categories. Useful parts and metal such as copper, plastics and lead that are recyclable are generally sold to recycling company. According to the recyclers they reuse and recycle each components and parts of mobile phones except the inactive parts which they sold as scrap and thereby recycle afterwards. Few wholesale buyers buy separate motherboard from a phone and store it temporarily and after a certain period of time they sale it to the foreign agents who are appointed by the foreign recycling company. According to wholesale buyers few Chinese recycling companies collect the motherboard from their respective agents. Wholesale buyers sell these motherboards to the agents BDT 240-260/kg. The scrap at times also includes some precious items such as

metal (copper, gold, silver, and platinum) and not so precious plastic items. Meanwhile both these items also moved to the chain for exporting.

The stakeholders who are related to the production of output of EOL mobile phones are performing the sorting, dismantling, refurbishing and recycling activities by informal means and in an inefficient way. Due to the dependence on ancient tools and equipment and the improper training of the repairman and recyclers the separation of precious components become ineffective. Very few of the workers have proper technical knowledge (which is limited to 3 months of diploma course) of dismantling and recovering of precious items from EOL mobile phones. Most of the workers learn by doing thereby contributing to the generation of more e-scarp due to mishandling.

Competitive Sector

The majority of the organizations operating in the end-of-life mobile phone sector (specifically wholesalers and retailers) are small and medium sized companies and run as family business with few full time employees. Due to the informal nature of this business activities, data related to EOL mobile phones' supply and demand is unavailable. This also contributed towards the apparent loosely defined competition pattern of this sector. The search for the collection of EOL mobile phones is not based on competition rather on mutual understanding of both wholesalers and retailers. In respect of the supply of EOL phones, the wholesales mentioned that the amount of supply is increasing day by day and in near future they expect more profit from it. The high obsolesce rate of repaired mobile phones, price and variety based competition are few on the contributing factors of these expected increasing supply of EOL mobile phones. Due to the low cost of EOL collections and the minimum wages of the repairman/employees the price of 2nd hand reusable mobile phones tended to be low. They also mentioned that the price of EOL mobile phones is not stable and changes from time to time. This suggest that the competition for reusable mobile phone buyers is relatively high than the competition for the supply of EOL mobile phones. Though the interviewees claim that the rivalry among them is not intense, in response to the question on future competition they are expecting high level of competition from new entrants. According to them, the geographical proximity of the competitor's and the low entry barrier to start the EOL mobile phone business is recently attracting lot of new entrants in this sector. However, mushrooming of this informal EOL recycling sector is less likely to attract private investors because of its economic non-viability and undefined and or ill-defined industry infrastructure.

Regulatory Sector

An enforced and monitored legal framework is important to design and implement an effective and efficient management of EOL products. However, currently in Bangladesh there is no specific regulation dealing with e-waste management. Bangladesh government

has passed and exercised few laws, acts and legal instruments to protect the environment issues, such as Environment conservation policy-1992, Environment conservation act-1995 and Environment conservation rules-1997; Ship breaking and Hazardous Waste Management Rules, 2011; Basel Convention-1993; Medical Waste Management Rules-2008; and National 3R Strategy for Waste Management-2009; none of them covered the electronic waste management issues categorically (Rahman, 2017). However, in the Import Policy Order 2015-2018, there is clause that puts an embargo on importing all kinds of e-waste. This contradicts with the decision to legalize the export of second hand electronic products (e.g., mobile phones and computers) under the Export Policy 2015-2018 (Dhaka, Tribune, 2013; Rahman, 2017). This consequently could make Bangladesh an attractive recipient of electronic waste unless it is categorically restricted through clauses added in the existing legal framework.

Different ministries, departments and local government institutions are working to address the environmental issues, formulating policies and implementations. Dhaka City Corporation –the only responsible authority for waste management in Dhaka, however, primarily functions around solid waste management leaving other types of waste management out of its functional scope. Although a conservancy inspector is assigned by the local government institution for each ward to look after the waste management, the inspection and support activities performed by them are inadequate. According Rahman, (2017), these enforcement bodies itself has serious lacking of resources and capacity to manage electronic waste separately. Therefore, the buying, refurbishing, recycling and reselling of the EOL mobile phones are not monitored by any authorized legal entities except few infrequent invasions by local police. The wholesalers and retailers mentions that- *these raids are managed by providing monthly subscription to this law enforcement agency. Moreover, they are not aware of the toxic effect of the things those they are handling. They also do not feel the need to have separate laws to manage these EOL products as they claim that this informal recycling process is safe and do not contain any toxic material harmful for their health.*

Few government and non-government organizations and special interest groups (e.g., media, newspaper, environmental activists, academia, government officials) have already started realizing the urgency of developing a sustainable e-waste management system and undertook some very tiny efforts. These efforts are intended to create awareness about e-waste management issues and its policy implications. However, such standalone efforts lack the coordination among related regulatory and enforcement bodies.

Organizational considerations

To explore the organizational considerations in this informal EOL mobile phone recycling system, interviewees were asked about their strategic planning and operational activities. Most of the operating organisations in this sector do not have adequate

planning in place relating to their cost structure. According to them- *the collection, refurbishment and reselling cost varies and therefore they depend on the cost plus margin approach to set the price of recycled, active and inactive parts.* These family owned business/one-man businesses are also not interested in setting clearly articulated business practices and procedures. Only the big wholesalers used to plan strategically, however concentrated on certain areas such as, forecasting the monthly supply of EOL mobile phone collections, assigning agents to collect EOL mobile phones from various input sources and negotiating with the export agencies regarding the recyclables.

The operating cost structure of this sector is low due to the low labour wage, usage of traditional equipment for refurbishment and recycling. For example, on an average a worker (e.g., repairman, recyclers) earns BDT 2000 to BDT 4000 daily for more than 10 hours of labour. Recycling and refurbishment is conducted by using the traditional hand-held tools such as pliers, hammer, chisel, screwdriver in a hazardous condition without any safeguard. The supply of EOL mobile phones is delivered by the input stakeholders to their shops which is stored in the shop and does not require any sort of warehousing facilities in other places. For example, the agents who collect the EOL mobile phone work on commission basis. Therefore, transportation and inventory costs are insignificant portion of the total costs and they never feel the need to estimate and plan in this regard. According to the wholesalers, *as they can recycle/resale almost 100 percent of the EOL mobile phones either as reusable phones or as scrap for recycling, they do not look for the quality of the EOL mobile phones.* They use to accept all types of mobile phone and later sort as per the saleability. Only a few of the big wholesalers admitted that- *the quality check of the supply of EOL mobile phones may enhance their supply of recyclable scraps to exporters.*

According to the interviewees, the capital investment, shop rent, shop maintenance costs, illegal donations are few of the major components of the total operating costs. The return on their capital investment mainly depends on the number of refurbishments and reselling of the EOL mobile phones. This means the supply of the EOL mobile phones plays an important role to economise the operating costs. An additional finding from the interviews suggest that few wholesalers get a continuous flow of the supply of EOL mobiles from the mobile phone retail shops due to their on-going business relationship with them.

Research Implications

This paper presents the reverse supply chain framework, its stakeholders and the task performed at each stage of the reverse supply chain of EOL mobile phones in Bangladesh. The framework presented in this paper provides a foundation for improving the role of the stakeholders in the reverse logistics flows of refurbishable and recyclable EOL mobile phones. It offers an insight into the refurbishing and recycling of EOL

mobile phones, specifically the sources, collection network, value adding process, output, the nature of competition and strategic cost structure. Comprehensively, this study identified the points of disintegration by categorizing the weakness and challenges and suggests the steps of coordination by identifying the ways to capitalize the existing opportunities (Figure 3).

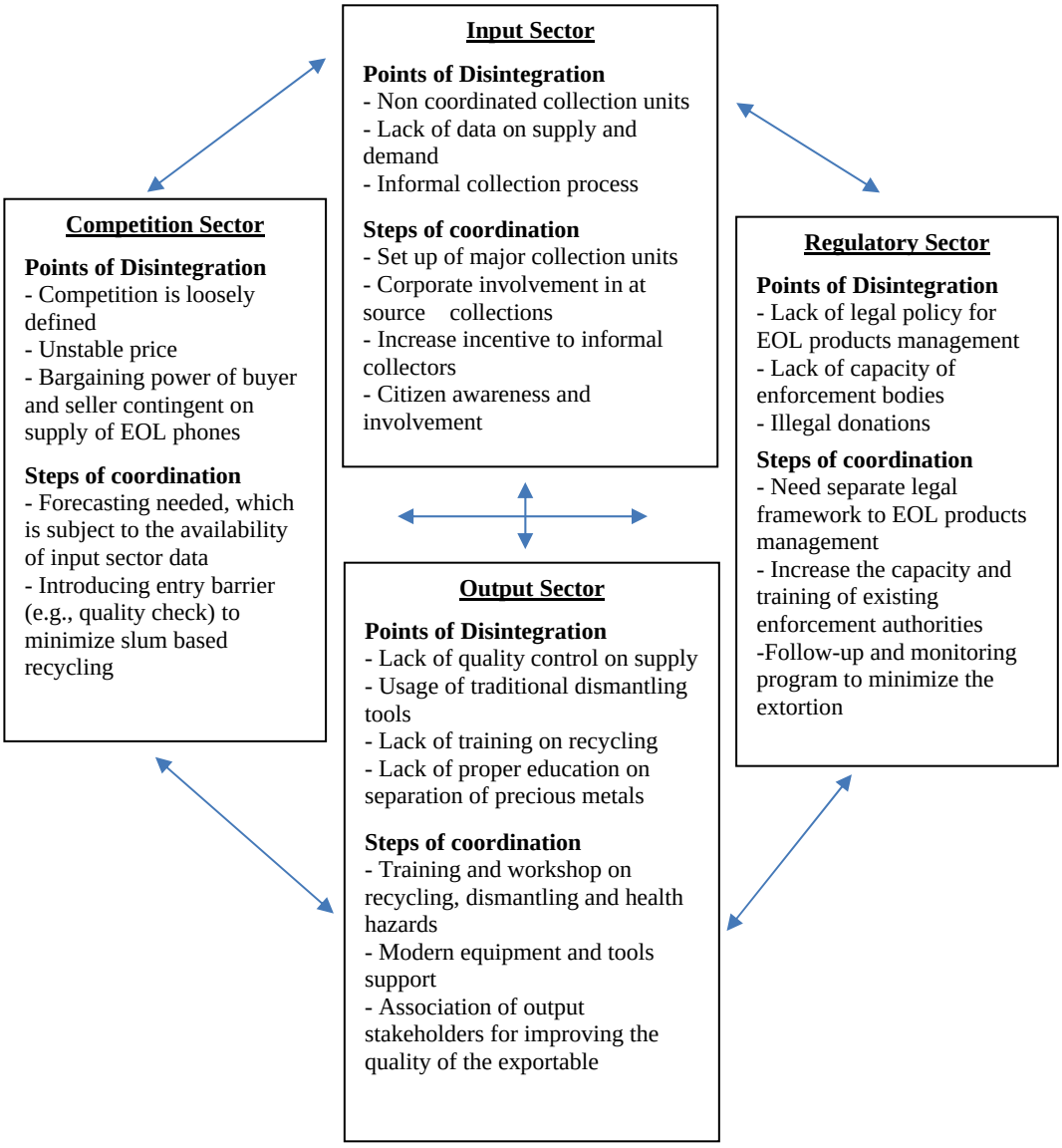

Figure 3: The links of disintegrations and suggested coordination among the stakeholders of EOL mobile phones

Despite the involvement of many organizations in the recycling of EOL mobile phones and the resulting significant tangible benefits, the management of this EOL mobile phones recycling is far behind compared to the benchmark of effective e-waste management system. The whole reverse logistics process of the EOL mobile phones such as collection, segregation, dismantling and recycling are performed by an informal sector. However, knemeyer et al. (2002) suggest that an effective and efficient reverse supply chain of EOL products largely depends on the system's ability to coordinate and integrate the supply and demand of recyclable by ensuring the cost effective and responsive supply chain activities such as transportation, material handling and choice of geographical location. In contrast to this view, the labour intensive EOL mobile phone recycling system in Bangladesh has serious lacking of strategic planning to coordinate the collection and value addition of the recyclables. This mandates the need to integrate the disintegrated loops and nodes of the existing informal reverse supply chain system. For example, existing government enforcement institutions and agencies such as city corporations, pourasavas, union parishads can plan and work in coherence with input stakeholders to manage the inbound and outbound distribution of the EOL mobile phones waste.

Since, the study suggests that the enforcement capacities of concerned institutions and agencies are weak, local government institution should plan for improving their logistic capacities (e.g., separate budget for e-waste management, segregation of e-waste at sources and monitoring the collection units) and provide training and education to the informal recyclers. These actions would help to reduce the impact of discarding and safe handling of harmful elements thereby contributing to the improvement of occupational health and safety in e-waste management. The active participation of the corporates and non-government institutions is also needed to create the awareness of e-waste hazards. For instance, multinationals operating in Bangladesh can promote the recycling activities by raising awareness and make people involved in recycling related activities. The efficient recovery of large volume of high quality recyclable is largely depends on citizen involvement. Many white goods manufacturers are currently offering an exchange programs to the customers (buy new in exchange of the old) and contributing to the coordinated collections of e-waste. This suggest that the input and output stakeholders need to work together by adopting both short and long term planning to manage the inflow and outflow of the EOL mobile phones waste.

The coordination of these input and output stakeholders is likely to be influenced by government rules and regulations. It is worthy to mention that Bangladesh is a signatory of the Basel Convention and in 2002 the signatories of the Basel Convention launched the Mobile Phone Partnership Initiative (MPPI) to promote sound management of EOL mobile phones. The intention of that program is to influence consumer behaviour towards more environmentally friendly actions; to promote the best reuse, refurbishing, material

recovery, recycling and disposal options and to mobilize political and institutional support for environmentally sound management. Though a ban was imposed on the import of used electronic goods in Bangladesh as per the country's Import Policy Order (IPO), it is unclear to what extent the ban is enforced. Therefore, to decouple the consequences of modernisation leap resulting from the digitised Bangladesh, the regulatory and law enforcement related stakeholders need to endorse e-waste regulations at the national level, create awareness of the issue among all stakeholders and adopt a self-sustaining e-waste management model for the country.

Conclusion

E-waste has been emerging as one of the most serious concerns in the last few years across the globe. However, the majority of the research as conducted in Bangladesh focuses on the estimation of e-waste, its problems and key challenges; little has been done so far on mapping the reverse logistic process of EOL products and understand the components and their interrelationships. This study partially fills this void by identifying both internal and external factors impacting the design and implementation of a reverse logistics of EOL products specially the end of life mobile phones in Bangladesh. This study provides an information base on the location of end of life mobile phones' supply sources, the procedures of repair and remanufacturing process, the locations of buyers and their expectations, the strategic thinking of the output stakeholders and the existing gap in regulatory sectors. A range of understanding such as understanding of the key internal and external factors, the role played by the stakeholders, the problems and challenges experiencing by the stakeholders and the point and reasons of disintegration as espoused in this study will enable the researcher to assess the economic viability of developing a sustainable end-of-life product management process in Bangladesh.

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