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Solid waste recovery supply chain networks – Structure and Operations [1,2]

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Abstract: In India, the recycling network is loosely netted with group of waste pickers, junk dealers, wholesalers and recyclers, especially waste pickers. This paper provide a comprehensive analysis of this supply chain in terms of its structure, price dynamics, volume of materials moved and its contribution to economic activity

Keywords: Supply chain management, Waste recycling

INTRODUCTION

The growing demand for recyclable materials from formal and informal organisations is creating many large recycling supply chain networks in different countries. In developing countries like India, the organisations willingness to take back used products and intention to operate closed loop supply chains to recover value is low. This is because of many reasons and one major reason is weak environmental legislation and its implementation. Also, the consumer awareness about environmental pollution and proper disposal of products is very low. The local governments of urban cities and towns are actually responsible for collection and disposal of waste generated by its citizens. But their system of collection and disposal is not efficient. Also there are many poor people living in these countries who are below specified poverty line. All the above form the reasons for the development and growth of numerous informal recycling supply chains for collection and recycling of solid waste generated by urban cities and towns.

Unlike in some developed countries, source separation of waste into bio-degradable and recyclable, is not enforced in India. The Municipal Corporations are statutorily responsible for solid waste management and they do not undertake segregation. The disposal pattern of solid waste and bio-degradable waste by the people living in cities and towns in India are mostly unstructured and poorly managed by local government bodies. People in general are not made aware of source segregation and waste management. Mostly people dispose their kitchen waste (food waste, vegetables and fruits, meat waste and other wet waste) along with non-biodegradable materials like metals, plastics, glass, polythene in a common basket or bag to the nearest collection drums kept by local administration.The local administration then takes this waste in a truck and dump into large waste yard allocated for this purpose. Beyond this, the local

administration does not take any initiatives for waste management and recycling. There are few cases where some local bodies have taken some initiatives to organize better waste disposal and recycling in collaboration with non-governmental organisations.

It is the waste-pickers and a network of informal traders and businessmen who perform the task of waste segregation and recycling facilitating task. The waste pickers in fact collect all types of solid waste generated by citizens in urban cities and towns. The material collected are paper, plastic materials, polythene bags, Iron and other metals, bottles and packing materials. These are the sold to junk dealers. From there these materials reach recyclers through a system of network of agents, transporters and storage places.The waste pickers make their livelihood by selling these wastes and they contribute large to environment by this activity.

Worldwide, millions of waste pickers form the basis of this supply chain. In Mumbai, India, the economic impact of waste picking has been estimated at nearly US $1 billion a year in the recovery of materials and the manufacture of products from them. The global economic impact of waste picking activities is likely to be of several billion US dollars annually.

The informal sector offers opportunities for survival to a large number of unskilled and semi-skilled migrants and local people in cities like Chennai and Bangalore. They are excluded from employment in the formal sector. Work in this sector is usually insecure, low earning and carried out under appalling conditions. Waste picking by these migrants and other people is a major economic activity which is largely unnoticed.

The paper is based on alarger study to investigate the functioning of the recycling supply chain in the city of Bangalore in the state of Karnataka. The recycling sector consists of economic activities like waste collection, waste trade and reprocessing and recycling of waste in different forms. A detailed inquiry into the functioning of this sector is expected to suggest the

existing supply chain structure, the economic activities involved and the total size of the market. It leads to future possible interventions to upscale the income, improve the conditions of work and to provide protection to the disadvantaged class of the sector.

The paper is divided into following sections:

1. Literature review
2. Methodology
3. Supply chain structure and mapping
4. Role of different entities in the supply chain
5. Conclusions and future works

REVIEW OF LITERATURE

A supply chain is a system of facilities and activities that functions to procure, produce, and distribute goods to customers. The efficient and effective movement of goods from raw material sites to processing facilities, component fabrication plants, finished goods assembly plants, distribution centers, retailers and customers is critical in today's competitive environment. Approximately 10% of the gross domestic product is devoted to supply chain related activities (Simchi-Levi, Kaminsky and Simchi-Levi 2003)

The reverse supply chain is one of the emerging areas of interest in the field of supply chain management. The reverse supply chain consists of list of activities involved in recovering used products for the purpose of recycling, remanufacturing and proper disposal by a manufacturer. Reverse supply chain or reverse logistics is the series of activities required to retrieve a used product from a customer and dispose of it properly or reuse after processing (Guide and Wassenhove 2002). The chain connects end users with manufacturer in reverse direction. Reuse and remanufacturing of products and materials are not new in the industry.

Wastepaper recycling, metal scrap brokers and soft drink industry are all examples that have been around for a long time. In these cases, recovery of the used products is economically more attractive than disposal. But, in the recent past, there is a growing interest in reuse and remanufacturing among industries and that lead to more studies in the area of reverse logistics. The major forces behind this development are:

1. Environmental legislation related to used product and waste disposal
2. Opportunity to recover some of the value from old products. e.g. Computer components
3. Opportunity to remanufacture old products and to serve secondary markets
4. Opportunity to become an environment friendly organization.

One major type of reverse supply chain exists in waste recycling. The general solid waste created by general public in urban cities and towns is in huge volume and the role of local government in proper handling and disposal of these waste were minimal. The poor people saw this as an opportunity to earn money and started collecting waste materials like plastic, polythene bags and covers, metals, papers, bottles and other materials from all garbage collection and disposal points. This resulted in a highly fragmented and complex waste recycling supply chain in the informal sector. There were many studies with respect to poor statue of these waste pickers from the social perspective.

The supply chain structure for paper recycling industry in India was presented in detail in this paper (Chandiran and Rao, 2004). It describe four levels in reverse supply chain namely source, buyers, wholesalers and recycling mills. It also provides detailed information on average stock, turnover per month, people employed and space used at each level. It also describes the

current practices of transportation, purchasing and negotiations. This paper highlights the role of waste pickers and other collectors of waste paper in the recycling of paper.

Medina (2009) described some of the issues pertaining to global recycling supply chains and waste picking in developing countries. It explains the contribution of scavenging in economic development and its positive impact on livelihood of poor people. Formalization of these waste picking activities are happening and it proposes different models namely Scavengers cooperatives, Micro-enterprises, Public-private partnership and so on.

Scheinberg et al., focus on development intervention on the status of waste pickers. It says that the best chance to support them is by helping in their professional context, and to support them in finding and entering the better and more stable economic niches that can open during the process of modernizing the waste management system. A detailed secondary materials chain was explained by Marchand (1998). The waste pickers sell their materials to Junk dealers who in turn sell it to Dealers and Brokers. These dealers and brokers supply to Recyclers and manufacturers.

Barros et al (1998) present a network for the recycling of sand from construction waste. Two types of intermediate facilities namely regional depots and treatment facilities have to be located. The model is a multi-level capacitated warehouse location model. Scenario analysis is used to cater for uncertainty in location of the demand points and in the return flows.

Caruso et al (1993) describe a solid waste management system, including collection, recycling and disposal. A multi-objective location-allocation model and some heuristics are used to plan the waste management system. The procedure results in the number and location of waste disposal plants, specification of the technology adopted and the amount of waste processed.

Besia et al., describe about the role of scavengers in solid waste management and proposed a systems dynamic model to evaluate different methods to bring these scavengers into formal waste recycling system.

From the above review, it is concluded that there was no study of this solid waste management from the perspective of supply chain dynamics. This paper deals with supply chain issues in terms of logistics, cost of operation, inventory, transportation and pricing.

RESEARCH METHODOLOGY

A descriptive method is followed in this study. The sampling process is summarized as follows:

To collect information with respect to this supply chain, the following information were collected about Bangalore city,. India.

City statistics:

Area : 800 Sq.KM

Population: (2008) : 7.8 million

Households: 2.5 million

No.ofwards : 198

It is estimated that Bangalore has approximately 25000 waste pickers. It is decided to collect data from 250 to 300 waste pickers which represent 1% of the population. It is also decided to go for stratified sampling based on wards so that uniform representation can be maintained. Each ward will represent a sample proportion to the density of the waste pickers.

Each ward has approximately 40 junk dealers and there are 198 wards. It is decided to have a sample size of 80 junk dealers for the study again with stratified sampling with proportionate sample size.

Mostly wholesalers are material specific and it is decided to have sample size of 40 wholesalers with each material segment representing proportionate sample size.

Validation of the data can be taken care by the following:

1. Internal validation (by WWT)
2. For a few zones, the survey can be repeated with the same sample after a time gap.

Supply Chain Structure and mapping

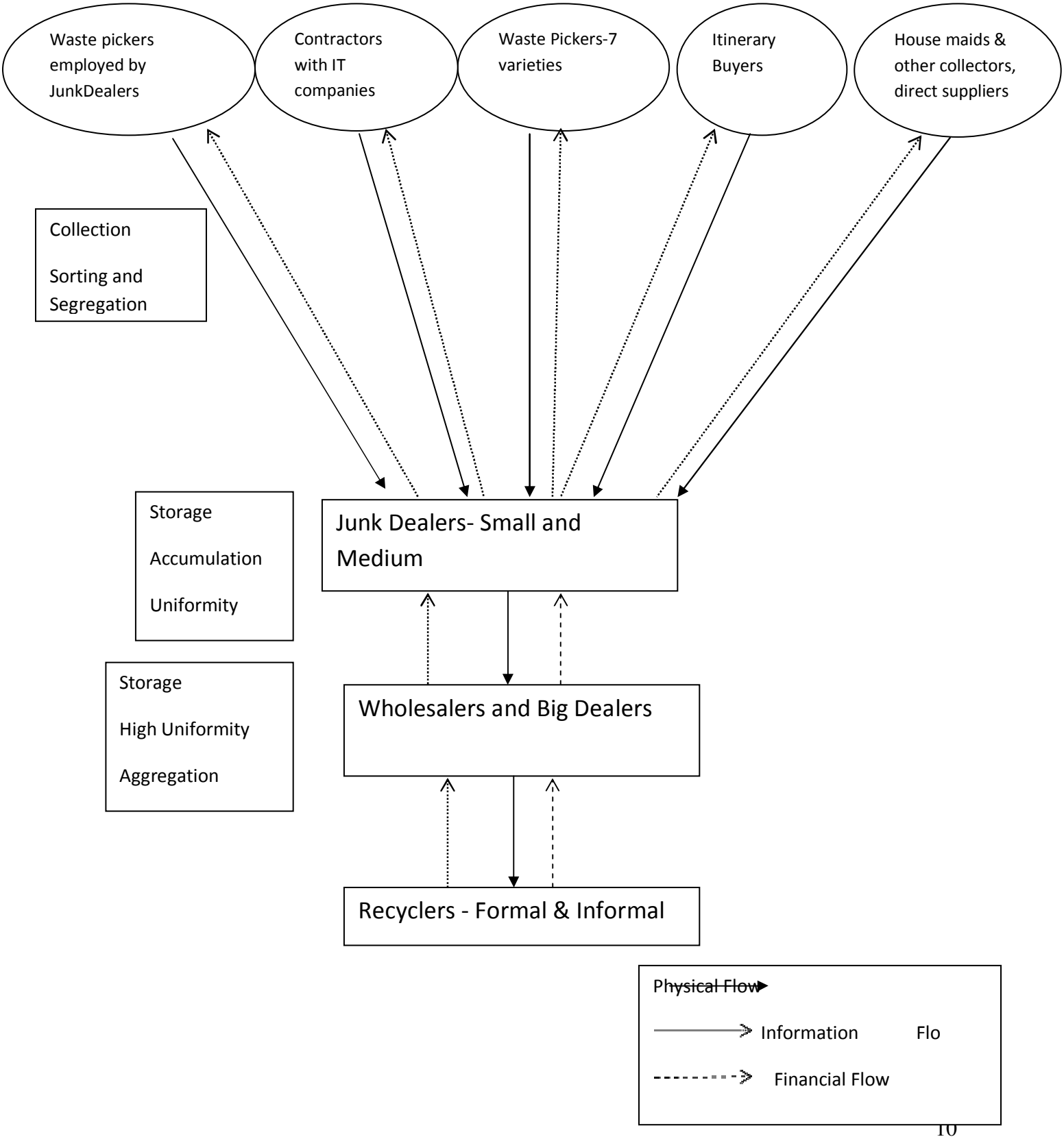
The role of each player in the waste recycling supply chain is given brief In Table 1 and Figure 1. The Table 1 also provide the details pertaining to activities performed in each stage and also cost details.

Table 1 Audit Process – Supply Chain Mapping

Node	Role played	Type of flows	Connect – Predecessor & Successor	Activity detail	Remarks
Waste Pickers	Collection of all kind solid waste from garbage dumping grounds of Municipal corporations and landfill sites. Some own tricycles. Move the solid waste to the place where they store and sorting is done.	Materials in different form	Junk Dealers (small & medium)	Collection and segregation of materials. Families are involved. Different types of waste pickers.	Migrant waste Pickers-3 types • Free roaming • Group employed by a dealer • Group employed by an Entrepreneur Local free roaming Waste pickers

	Sold to Junk dealers. Payment immediate.				Local employed by an entrepreneur Landfill workers Contracted municipal waste collector-Drivers and employees of contractors also getting a share
Junk Dealers-local (small & medium)	Multi-item dealers, Buys from different sources, Have a small shop, open storage, some have vehicles to send materials to wholesalers.	Physical Materials	Waste pickers – upstream and Big Junk dealers and Wholesalers who deal with one or two materials downstream	Weighing machine used. Collect materials and give money. Sorting, accumulation and disposal. .	Rent to be paid for the shop
Big Junk dealers and Wholesalers who deal specifically with one or two materials	Mostly specialized in one material like paper. Sorting and packing	Physical & Information	Recycling plants and agents in downstream and Junk dealers in the upstream	May own their LCVs and trucks for delivery Pay sales tax Approval from authorities Association also exists.	Own enough space for sorting and storage. Own some simple machines for packing and conversion for easy transportation
Recyclers(small, medium and big)	Covert waste into some useful materials and products.	Physical, Information & Financial	Wholesalers in upstream And secondary market, other industries in downstream	Most of them are Small players operate without proper govt approval; Paper recyclers are big and approved by Govt.	

Figure 1 Waste Recycling Supply Chain



Role of Waste Pickers:

There are many types of waste pickers and the proportion interviewed is given in Table 2.The average price at which they sell to Junk dealers is given in Table 3. The collection quantity is more for waste pickers who work under some Junk dealers than independent waste pickers. Most of them are getting their payment for junk sold on the same day from Junk dealers. Few of them own some ordinary tri-cycles to collect the waste and transport to nearest dealers. All the waste collected in a day is sold in the same day. There is no storage taking place with waste pickers.

These waste pickers are very important in this value chain because the segregation of waste takes place at this level. These people do the segregation either at the collection site or at their homes. Some of them also do it at Junk dealer's place. This is very important value addition but the money they earn is not proportionate to their effort. They work in most unhygienic conditions without any protection. The materials like polythene bags, papers of different grades, bottles, plastics are separated and sold to Junk dealers.

Table 2 :Wastepickers profile

Type of Waste pickers	Number interviewed
Contractor municipal worker	34
Landfill workers	2
Local under an entrepreneur	35
Local-independent	146
Migrant under an Entrepreneur	2
Migrant under dealer	17
Migrant-independent	66
Grand Total	**302**

Table 3 : Price of materials

Material	Price at which they sell to dealers (in Indian Rupees)	Ave Qty collected per day
Paper Lower Grade (LG) (per KG)	Rs.4	10-15 kg
Paper Higher Grade(HG) (per KG)	Rs 7	
Plastic HG (per KG)	Rs. 12	5 kg -10 kg
Plastic LG(per KG)	Rs.3 to Rs 5	
Polythene HG(per KG)	Rs.3 to Rs 5	5-10 kg
Polythene LG(per KG	Rs 12	
Metals (per KG)	Rs.6 to 30	0-5 kg
Bottles(per No)	Rs.1.50	15 nos.

Table 4: Exact quantity of waste collected and the number of waste pickers

Material	0-5 kgs	6-10 kgs	11-15 kgs	16-20 kgs	More than 20 kgs.
Paper HG	226	61	8	1	3
Paper Boards	210	68	10	1	1
Paper LG	202	43	1	-	1
Plastics HG	259	25	3	-	-
Plastics LG	244	7	1	-	-
Polythene HG	269	26	-	-	-
Polthene LG	221	38	-	1	-
Metals	264	4	11	1	-
Beer Bottles	247	37	6	-	2
PET bottles	220	40	2	1	-
Other bottles	206	28	1	-	1
Electronic items	90	2	1	-	-

From Table 4, we can find that Paper High Grade (HG), Paper boards, Paper (Lower grade)LG and Beer bottles are the ones that are collected by most of the waste pickers. The Table 4 also indicates that the total quantity collected by the majority of the waste pickers fall in the category of 0-5Kgs. The quantity collected for the next category 6-10Kgs is less than 50% of the 0-5Kg category for all material types.

It would be interesting to see if there is any difference between quantity of material collected of a particular material and the type of wastepickers. But the analysis indicated that there is no difference between the two.

Revenue Earned by the waste pickers

The amount of collected waste is the only source of revenue for the wastepickers. The revenue earned by the waste pickers per kg (except bottles where it is for per bottle) for different materials was analysed and an overall summary of observations is given in Table 5:

Table 5: Revenue per Kg

Material	Rate per Kg(Min&Max) For majority
Paper LG	2-4
Paper boards	4-6
Plastics HG	6-14
Plastics LG	3-4
Polythene HG	10-12
Polythene LG	2-3
Metals	10-16
Beer Bottles	1-2.5 (PerBottle)
PET bottles	7-18
Electronic items	10-15

Table 5 reveals some interesting facts. For some materials like Paper LG, Paper boards the majority of waste pickers revenue fall in a narrow range. But for other materials like Plastics HG, Metals and PET bottles, the revenue earned per Kg varies widely. A narrow range indicates the true revenue earned per Kg obtained from survey may be close to the actual revenue earned per Kg. This may also indicate that there is no significant relationship of the revenue earned for a material and other demographic information. On the contrary, if the range is widespread we need to look at if there is any relationship between revenue earned and some other demographic information like type of waste picker, or area of waste pickers and so on. In other words, we need to further probe the data to see the relationship.

So, in continuation with the previous analysis, we further probed to find if there is relationship between revenue earned and demographic variables for materials which show wide interval. Specifically, the analysis was done for the Plastics HG, Metals and PET Bottles which seem to be high revenue earning materials.This was carried out by first looking at the type of wastepicker and revenue earned. First, we will present the total number of wastepickers who fall in different revenue categories. The following Table 6 summarises the data:

Table 6 Revenue earned per Kg of Plastic HG for different type of wastepickers

Plastics HG	**Count of Revenue earned per Kg**																
Row Labels	**0**	**4**	**5**	**6**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**20**	**Grand Total**
Contractor municipal worker	4	4	7	5	2		5			6							33
Landfill workers	1																1
Local under an entrepreneur	5			20		5	1		1		1	2					35
Local-independent	1	4	5	10	9	5	18	1	10	14	30	1	23	1	12	1	145
Migrant under an Entrepreneur							1			1							2
Migrant under dealer						1	10		4		2						17
Migrant-independent					13	3	26		11	6	4	3					66
Grand Total	**11**	**8**	**12**	**35**	**24**	**14**	**61**	**1**	**26**	**27**	**37**	**6**	**23**	**1**	**12**	**1**	**299**

The Table 6 clearly depicts that there is no clear relationship between type of waste pickers and the revenue earned because the spread is uniform across different catergories.

Wastepickers revenue per week

Wastepickers revenue for a week is estimated using the buying price of the junk dealers. This is because the data revealed by junk dealers on buying price may be a good indicator of selling price of wastepickers though we have collected data on this. Table 7 provides comprehensive revenue structure for waste pickers.

Table 7: Revenue estimation per week for wastepickers

Material	Quantity /day collected (Kg)	Selling price (from junk dealer data)	Min Revenue /day	Max Revenue/day	Min Revenue/ week	Max Revenue/week
Paper HG	5	6-8	30	40	210	280
Paper Boards	5	4-6	20	30	140	210
Paper LG	5	3-5	15	25	105	175
Plastics HG	5	10-12	50	60	350	420
Plastics LG	5	3-4	15	20	105	140
Polythene HG	5	10-12	50	60	350	420
Polthene LG	5	2-3	10	15	70	105
Metals	5	12-16	60	80	420	560
Beer Bottles	5	2	10	10	70	70
PET bottles	5	10-12	50	60	350	420
Electronic items	5	15	75	75	525	525
Total			385	475		

Junk Dealers

Junk dealers form the secondary stage of waste collection after the wastepickers. The junk dealers are not only deal with waste pickers but also receive waste material from other sources like companies, offices, khabadiwalas and Individuals. They used to have small storage space with roof and also open space to store materials. There are two types of Junk dealers big and small. The volume of material handled per month varies from dealer to dealer. They used to a weighing machine and a small cart of vehicle to move the materials to wholesalers. Most of

them receive the payment within a week after selling their material to wholesalers. Some small junk dealers sell their materials to big junk dealers nearby in order to avoid transportation cost.

Table 8: Price for junk dealers based on pilot study

Material	Quantity	Price at which they buy from waste pickers	Frequency of sellingto Wholesalers	Quantity accumulated before selling-BIG dealers	Quantity accumulated before selling-SMALL dealer
Paper	80 to 100 kgs	Rs. 4 to 6	Once in a week	500 kgs	21 to 30 kgs
Plastic	60 to 80kgs	Rs.3 to 12	Once in a week	250 kgs	10 to 20kgs
Polythene	50 to 60 kgs	Rs.3 to 12	Once in a week	250 kgs	10 to 20kgs
Metals	10 to 25kgs	Rs. 10 to 25	Once in a week	50 kgs	10 to 20kgs
Bottles	50 no's	Rs.1.00 to 1.50	Once in a week	150 bottles	60 bottles
Electronic items	10 kgs	Rs.6	Once in a week	10 kgs	5 kgs

Table 9:

Percentage of Waste coming from waste pickers													
Ward Name	**0**	**4%**	**10%**	**20%**	**25%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**100%**	**Grand Total**
Banasangari							1						1
Basavanagudi							1		1				2
Basavanagudi, Thiyagarajnagar(T.R.Nagar)			1				1						2
Bommanahalli				1			2	1	2				6
Bommanahalli, Silk board								1	1	1			3
C.V.Ramannagar, Indira nagar							1	1	1				3
Chickpet, K.R.Market											3		3
City market, Chickpet			1	1									2
J.P.Nagar									1				1
Jayanagar			1					1		1			3
Kalyannagar, Banaswadi						2							2
Krishnarajapura						1		2					3
Lingarajpuram		1				1		2		1			5
Mahadevapura, Krishnarajpuram				1			1		2				4

Malleshwaram				1				2					3
Mysore road, Azadnagar,							1						1
Mysore road, Bapujinagar, Nayandahalli, Azadnagar	4		2		1		1	5			2		15
Nagawara				1									1
R.T.Nagar	1		3	5	1	1		1			1		13
Rajajinagar						1	1	2	1				5
Venkateshpuram						1		4	1	4		2	12
Vivaknagar, Shanthinagar								1					1
White field	1												1
Grand Total	**6**	**1**	**8**	**10**	**2**	**7**	**10**	**23**	**10**	**7**	**6**	**2**	**92**

The survey results summarised in the Table 9 outlines the percentage of waste collected by junk dealers that come through the wastepickers. It is clear that they receive 40% to 60% of waste from the wastepickers. The percentage of waste collected from the rest of sources are summarised below:

Table 10: Percentage of collection from other sources

Source	Percentage of Collection
Employees	10-20%
Company contractors	10-20%
Individual	0 - 40%

Cost of operations

The table 12 provide information about the buying rate from waste pickers. Apart from this cost of materials, there are other costs related to transportation, wages and wages. The cost of operations involve paying rent to the place, labour cost, money to police and transport cost. Almost all of the junk dealers pay an average of Rs.500 to police for smooth conduct of day-day operations. Only about 20% of the junk dealers have said that they maintain vehicles for

operations and they pay on average of Rs.500 for maintaining vehicles.All the junk dealers interviewed incurred transportation cost for selling the materials. The majority of junk dealers seem to spend about Rs.1000 for transportation every month.Also they pay an average of Rs.2000-4000 per month for the rent.The junk dealer on average spends between Rs.4500-5000 on labour per month. Table 12 provides calculation of revenue for all the material for Junk dealers.

Table 11: Rate per kg of materials bought from waste pickers for different materials

Material	Rate per Kg(Min&Max) For majority of junk dealers
Paper HG	6-8
Paper LG	3-5
Plastics HG	10-12
Plastics LG	3-4
Polythene HG	10-12
Polythene LG	2-3
Metals	12-16
Beer Bottles	2/bottle
PET bottles	10-12
Electronic items	15

Table 12: Revenue per kg for junk dealers and buying price

Material	Buying Price Min	Buying Price Max	Minimum Selling price per KG	Maximum Selling price per KG	AvgQty Collected /day
Paper HG	6	8	10	12	20
Paper Boards	4	6	6	8	20
Paper LG	3	5	2	9	20
Plastics HG	10	12	10	18	20
Plastics LG	3	4	3	8	20
Polythene HG	10	12	8	20	20
Polthene LG	2	3	3	6	20
Metals	12	16	12	30	20
Beer Bottles	2	2	2	3	20
PET bottles	10	12	10	20	20
Electronic items	15	15	15	30	20

Revenue estimate for junk dealers were obtained based on the buying price data of wholesalers. Using the revenue per kg for each material, two revenue projections namely Minimum revenue per week and maximum revenue per week were obtained. The data is given below in the table 14 along with the cost of operations and profit.

Table 13: Revenue per day and Profit/Loss for junk dealers

Minimum Revenue/Day	Maximum Revenue/Day	Minimum Revenue/week	Maximum Revenue/week	Cost of operations per week	Profit
80	80	560.00	560.00	Money to police - 125	**Loss** (using minimum revenue) = **1550**
40	40	280.00	280.00	Rent-750	**Profit** (using maximum revenue) = **1750**
-20	80	-140.00	560.00	Maintenance-	

				250	
0	120	0.00	840.00	Labour-1125	
0	80	0.00	560.00		
-40	160	-280.00	1120.00		
20	60	140.00	420.00		
0	280	0.00	1960.00		
0	20	0.00	140.00		
0	160	0.00	1120.00		
0	300	0.00	2100.00		

Wholesalers

Wholesalers are collecting specific materials from Junk dealers and supply to recyclers. They are specialist in one or two materials only like Paper or plastic. The volume handled and turnover varies widely with respect to the materials. The price at which they buy materials from junk dealers varies with respect grade or quality of the material. For example, polythene bags with less thickness attract less price compared milk covers with more thickness. To get a clear picture it is necessary to collect more data.

Wholesalers Profile

Almost all the wholesalers get their material from junk dealers. Very few get materials like paper from offices and factories directly. Many wholesalers deal with all kinds of waste but it is found that for materials like Paper and Plastics, there are exclusive wholesalers. The number of wholesalers met and their category are given in Table 14.

Table 14: Type of wholesalers

S.No	Type of whole salers	Numbers
1	All scraps	15
2	Plastics and PET bottles	9
3	paper	8
4	Bottles(beer)	1
5	Milk covers	1
6	Tissue paper	1

The wholesaler who handles all kind of scrap handles less volume for each category of material. But exclusive wholesalers handle huge volume of their material. The table 15 shows the collection quantity of wholesalers for all scrap items per day. In the case of paper, there are exclusive wholesalers who deal large volume of papers in the range of 1 tons per day. Similarly there are big wholesalers in the category of plastics and polythene materials.

Table 15 Quantum of materials handled by wholesalers

Materials handled per day	No.of wholesalers					
	Paper	Plastic	Polythene	Metals	Beer Bottles	Electronic items
< 100 Kgs	8	8	9	11	12	9
100-500 kgs	8	8	7	2	6	1
500-1Ton	10	5	6	2	3	1
Total	**26**	**21**	**22**	**15**	**21**	**11**

Each wholesaler run the business with some limited open and closed space. The amount of space used varies from huge yard to small shops. Mostly large space is used by exclusive wholesalers. There is no fixed limited size and the size varies from individual to individual wholesalers.The total space used by the wholesalers varies widely depends on the size of the wholesaler's operation. It ranges from 500 Sq. Ft. to 60000 Sq. ft. Most of the space is used for stocking the material before the sales and on average they own a space of 2000 to 5000 Sq.ft.

The wholesalers sell all the material either to factories who recycle these materials or to some big wholesalers who in turn send these materials to other recycling factories and companies. It is noted that the number of levels in the reverse supply chain not strictly revealed as in this case wholesalers again in turn sell the material to higher level wholesalers before reaching concerned recyclers. Similarly small junk dealers sell to large junk dealers who in turn sell to wholesalers. Table 16 gives the summary.

Table 16: Disposal distribution

Disposal Destination	No. of wholesalers
Factories	21
Big Wholesalers	15
Grand Total	**36**

Many of the wholesalers spend significant money on labour and transportation. The expenses are more for wholesalers because he needs a larger space, more workers and significant increase transportation.Most of the wholesalers do not entertain any demand from police and other authorities. There are about 10 wholesalers who responded that they are giving bribes to authorities and the range varies from Rs.500 to Rs. 5000 per month.

The average transportation cost for a wholesaler is Rs.7000/ per month but it varies to higher level for bigger wholesalers. The lowest value is Rs.2000 and the highest was Rs. 30000.Since many wholesalers outsource transportation, there was no maintenance cost. But if they own vehicles, they spent on maintenance of vehicles. Mostly they own trucks and the cost was proportionate to number of vehicles. The average amount spent on this Rs.3,500/-.

The average rent was Rs 5200 per month but the rent varies from area to area and also depends on the space. There are few wholesalers who run their business in their own place. The labour cost is higher for the wholesalers and by average it comes to Rs.17, 200 for a wholesaler. There are big wholesalers who pay Rs.30000 to Rs.50000 for labour alone. The labour cost is directly proportional to number of people employed by them. The labour cost per worker is approximately Rs 3000 to Rs 4000 per month.

- The number of labour /people working for the wholesalers ranges from 1 person to 15 persons but majority of them employ 3-5 people.
- The payment period from recyclers and big wholesalers ranges from 1 week to 2 weeks.
- Many of the wholesalers involved in giving financial assistance to Junk dealers and other suppliers. Normally this credit is adjusted against materials over a period of time.
- Similarly many wholesalers avail assistance from recyclers. Even some people get up to Rs. One lakh as assistance from recyclers.

The wholesalers own different types of vehicles for both inbound and outbound transportation. The different transportation options used are tricycles, light commercial vehicles (small trucks) and big trucks. 10 wholesalers use tricycles, 15 people own their own trucks and 6 people own small trucks.

The initial investment made by wholesalers varies from minimum of 50,000 to 3 Lakhs. Majority of them have invested between 1 Lakh to 2 Lakh. The investment is for the shop, vehicles and weighing machines.

Table 17: Buying rate for Materials from Junk dealers and other sources

Material	Maximum per KG	Minimum per KG	Range	Mean Price
Paper/Paper boards LG	9	2	7	6.12
Paper/Paper boards HG	12	10	2	11
Plastics LG	8	3	5	4.5
Plastics HG	18	10	8	14.5
Polythene/LG	6	3	3	3.7
Polythene/HG	20	8	12	14.5
Metals	30	12	18	17.36

Bottles/Beer	3	2	1	2
PET Bottles	20	10	10	14
Electronic items	30	15	15	20

The buying price rate of different materials from Junk dealers and other waste material suppliers is given above in Table 17. There exists a large variation in buying price for the same material across different wholesalers.

Table 18: Revenue Projection for a week for Exclusive Wholesalers

Material	Pessimistic	Optimistic	Most Likely (1)	Most Likely (2)
Paper HG	0	40000	20000	20000
Paper LG	-120000 (Loss)	320000	120000	80000
Plastics HG	4000	24000	20000	8000
Plastics LG	16000	48000	36000	28000
Polythene HG	78000	162000	150000	90000
Polthene LG	114000	162000	132000	144000
Metals				
Beer Bottles	7000	10500	10500	7000
PET bottles	7000	52500	42000	17500
Electronic items				

Revenue Projection for Exclusive wholesalers:

The revenues are projected after considering the price variations in buying and selling the materials. The buying price for a material from a Junk dealer varies widely and hence both higher price and lower price are considered for each material. Similarly the wholesaler sells the material to recyclers or big agents. This price also varies and hence the maximum selling price and the minimum selling price are considered. The revenues projected are calculated using the following formula

Revevue per material=

(Selling price per KG-buying price per KG) x Total material collected per week

The exclusive wholesalers are handling only limited materials like paper and plastics. Many wholesalers handle only two materials. So, these wholesalers deal large volume and less variety. The cost incurred by wholesalers is given in the following table. It is assumed that big wholesalers are mostly exclusive wholesalers and small are multi-material wholesalers. From the revenue the cost is deducted and the final profit per month is projected as shown in table given below.

Total Expenses:

So, typically for a wholesaler who is small, the total expenses calculated as per the table. A big wholesaler almost spends three times the small wholesaler. The major cost is labour cost.

Table 19: Cost of operations

Type	Money to Police/Authorities	Transportation	Maintenance	Labour	Rent	Total cost per month
Small	500	3000	1200	5700	3760	14160
Big	1000	11200	4000	25700	8570	50470

Table 20: Profit Projections per month for Exclusive Wholesalers

	Profit			
	Optimistic	Pessimistic	Most Likely1	Most likely2
Paper	1389530	LOSS	509530	349530
Plastics	237530	29530	173530	93530
Polthene HG	597530	261530	549530	309530
Polythene LG	597530	405530	477530	525530
Beer & PET bottles	201530	5530	201530	47530

Table 21: Revenue and Profit Projection for Exclusive wholesalers:

Common wholesaler Profit Projections				
Material	Optimistic	Pessimistic	Most Likely1	Most likely2
Paper HG	3000	0	1500	1500
Paper LG	6000	-2250	2250	1500
Plastics HG	6000	1000	5000	2000
Plastics LG	12000	4000	9000	7000
Polythene HG	27000	13000	25000	15000
Polthene LG	40500	28500	33000	36000
Beer Bottles	3000	2000	3000	2000
PET bottles	15000	2000	12000	5000
Total Revenue per month	450000	193000	363000	280000
Cost	14160	14160	14160	14160
Profit	435840	178840	348840	265840

Table 22: Comparison of profit between Exclusive wholesalers and Common wholesalers

	Paper	Plastic	HG Polthene	LG Polthene	Beer & PET	Common wholesalers	
Optimistic	1389530	237530	597530	597530	201530	435840	
Pessimistic	LOSS	29530	261530	405530	5530	178840	
Most Likely1	509530	173530	549530	477530	201530	348840	
Most likely2	349530	93530	309530	525530	47530	265840	

Table 23: Average Quantity collected by wholesalers

Material	Exclusive Wholesaler AvgQty Collected /week in kgs	Common wholesaler Ave.Qty collected in kgs
Paper HG	10000	750
Paper LG	40000	750
Plastics HG	2000	500

Plastics LG	4000	1000
Polythene HG	6000	1000
Polthene LG	6000	1500
Beer Bottles	3500	1000
PET bottles	3500	1000

Summary and Conclusions:

1. Quantitycollected by waste pickers is < 5 kg for all materials.
2. Local independent wastepcikers form maximum sample.
3. It seems there is no relationship between type of material collected and type of wastepickers.
4. For some materials like Paper LG, Paper boards the majority of waste pickers revenue fall in a narrow range. But for other materials like Plastics HG, Metals and PET bottles, the revenue earned per Kg varies widely.
5. There is no relationship between revenue per kg and the demographic profile for wastepickers.
6. Wastepickers in Nagawara earn more in the case of plastics than any other area.
7. Revenue by migrant independent wastepickers seems to be less than revenue made by local independent waste pickers for plastic and metal items.
8. Wastepickers living in the outskirts of Bangalore earn more than other wastepickers.
9. Nearly 60% of solid waste collected by junk dealers come from wastepickers.
10. It is found that there are two kinds of junk dealers big and small based on the quantity of materials collected.
11. Based on the data, it seems junk dealers end up in loss for commonly collected materials paper (HG/LG), paper boards, plastics (HG/LG) and pet bottles.

12. It is observed that there are wholesalers who deal with only one kind of materials (Exclusive wholesalers) and there are wholesalers who deal with many materials(Common wholesalers).
13. Wholesalers who deal with Paper and Polythene exclusively make huge profit compared to other materials.
14. Exclusive wholesalers who deal with plastics and PET bottles making less profit than common wholesalers.
15. The price determination between any two players is mainly determined by market forces and not by any individual company or agency. This supply chain is featured with loose linkages with no long term relationships.

This study excludes the role of recyclers both in formal and informal sectors. This study is used to make policy decision with respect to welfare of waste pickers and also how they can move up in the value chain. This work is taken for further research and a business model to be developed based on the work for this sector. No policy guidelines are proposed in this paper but based on this facts, it is proposed to formulate policy note on integration of this supply chain with formal network of waste collection and recycling.

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