ASOCIACION ARGENTINA
DE ECONOMIA POLITICA

ANALES | ASOCIACION ARGENTINA DE ECONOMIA POLITICA

XLVIII Reunión Anual

Noviembre de 2013

ISSN 1852-0022
ISBN 978-987-28590-1-5

POLICIES TO IMPROVE MUNICIPAL SOLID WASTE MANAGEMENT ON BUENOS AIRES METROPOLITAN AREA

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Policies to improve Municipal Solid Waste Management on Buenos Aires Metropolitan Area*

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July 2012

Abstract

This paper tries to determine what policies may improve municipal solid waste management in terms of efficiency and sustainability in the Metropolitan Area of Buenos Aires. With this purpose, it attempts to calculate the total external cost of waste disposal on each province of the country using Fullerton (2005) methodology in order to obtain the optimal tax and the total potential revenue. Finally, focusing the general equilibrium model by Fullerton and Kinnaman (1995), and with a critical analysis of the current state of solid waste management on the region, this work discusses about what policies can be implemented.

Este trabajo busca determinar qué políticas podrían mejorar la gestión de residuos sólidos urbanos en términos de eficiencia y sustentabilidad en el Área Metropolitana de Buenos Aires. Con este propósito, se calcula el costo total externo de disponer residuos en cada provincia argentina, utilizando la metodología propuesta por Fullerton (2005) para obtener el impuesto óptimo y los ingresos potenciales. Finalmente, centrándose en el modelo de equilibrio general de Fullerton y Kinnaman (1995), y con un análisis crítico del estado de situación de la gestión de residuos sólidos en la región, este trabajo discute la qué políticas pueden implementarse.

KEY WORDS: SOLID WASTE, ENVIRONMENTAL, PRICING POLICIES, MARKET FAILURES
JEL Clasification: H23 K32 Q51 Q58

1 Introduction

Nowadays, waste management is consider of vital importance because its consequences on health and environmental preservation. The lack of a law that prohibits waste disposal on the kerbside, the imperfection of property rights related with the existence of transaction costs and the presence of a natural monopoly make place to several market failures. Efficiency is only possible when the private marginal cost reflects the true social marginal cost. But in presence of market failures, efficiency can not be achievable because when prices are determined by the market, they diverge from the true social marginal cost.

*This paper is based on the BA Thesis presented at Buenos Aires University

†Thanks: To Professors Fernando H. Navajas and Enrique L. Kawamura for tutor and support and to CEAMSE staff, specially to Dr. Armando Schiavi, Dra. Viviana M. Palópoli and Lic. Alicia Álvarez for their willingness to help.

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On the next section, and to evaluate social cost, this paper uses Fullerton(2005) methodology based on cost control method. Basically, this author states that the total social cost per bag of waste is equal to the private price and the optimum tax. One of the main objectives of this work is to give a rough idea about how much the total external cost on each province of Argentina is, in order to calculate the optimal tax and its correspondent potential revenue.

The idea is to give policy makers new tools to decide what policies they can implement. One shocking result is that regarding that Buenos Aires is the most populated province, it has not the maximum total external cost. Misiones has the maximum total external cost because it has highest temperatures and precipitation levels. That's the reason why it has the greatest values of the optimal tax. However, in terms of potential revenue, Buenos Aires is the province that has more potential welfare gains.

It must be mentioned that these calculations have only the purpose to show what can be done, and are not an exact measure of environmental losses.

Many studies had been made to understand and explain the determinants of waste generation and the individual decisions about how to dispose it. Oldest studies dated from the seventies, where the role of a fix tax had been questioned by Wertz (1976). Richardson and Havlicek (1978) concluded that waste generation depends positively on income, age and size of household, and negatively on ethnic origin.

Between the policies proposed to deal with waste generation are the unit pricing policies. Some authors defended the unit pricing, such as Deisch (1989), Watson (1989), Riggle (1989), Skumatz (1989), Morris and Byrd (1990), Jenkins (1991) and even the Environmental Protection Agency of United States through its works EPA (1990) and Inside EPA (1990). However, Alderden (1990) and Browing and Becket (1990), among others, considered unit pricing problems, as illegal dumping, excessive compact of waste, greater incidence of the tax on low income households, etc, and proposed education campaigns, blocking commercial dumps, and mechanism of control and enforcement. Skumatz (1991) and Andersen (1992) coincided that it is not the volume based tax but the weight based tax that gives the correct measurement of the real cost of disposal, while Cutherbert (1992) stated that unit pricing effects depends on social, demographic and economic factors of each community.

In response to unit pricing issues, Fullerton and Kinnaman (1995) proposed a theoretical model showing a Deposit-Refund System as an alternative policy. This system consists on an excise tax and a subsidy for recycling and disposed materials. Thus, the consumer pays indirectly for the illegal dumping, and directly for the social marginal cost of each unit of waste generated. Given that this system leads to the same amount of revenue as an optimum tax system (where improper disposal can be tax), this gives the opportunity to evaluate the implementation of a Deposit-Refund system on Argentina, as way to internalize the environmental damage previously calculated.

With this purpose, Section 3 presents the main results of Fullerton and Kinnaman (1995) model with some of the conclusions of Fullerton (2005) regarding to its implementation.

Section 4 evaluates implementation issues regarding national wide policies on one hand, and local policies on the other. This last subsection focuses on waste management of Buenos Aires Metropolitan Area, the agglomerate compound by the City of Buenos Aires and a set of jurisdictions of the province.

According to the latest information from the National Population and Household Census (2010), Gran Buenos Aires has 32% of the Argentine population, while only a 7% lives on the city. While much of the metropolitan area population lives in the *Conurbano*, according to the Subsecretary of the Metropolitan Office of Buenos Aires City Government, near 22 million trips are made per day to and from the city because population from the province has half the jobs there.[1] Thus during the day, the City of Buenos Aires is home of a large part of the population of the province, which has its workplace in the city,

[1] Valenzuela (2012)

consuming and generating waste there.[2]

Since the calculation and the model both depend on several assumptions, evaluating the policies on the current situation of the region presents several questions: Can we adapt our reality to fulfill the assumptions? If the assumptions are not fulfilled, are the conclusions valid? What policies can be applied?

This work attempts to answer some of those questions on Section 4, and concludes on Section 5.

2 Rough Calculation of an excise tax

2.1 Data and methodology

In order to compute the total external cost of the different provinces of Argentina with Fullerton(2005) methodology, several sources of data had been used. First, National Population and Household Census 2010 provided population amounts of each province to elaborate a population ranking, while National Meteorological Service information gives temperature and precipitation averages from decade 2001-2010 to built temperature and precipitation rankings. Each ranking orders provinces from 1 to 23 giving high scores to least populated province, coolest province and the province with least precipitation levels.

Miranda and Hale (1999) provided ranges of environmental cost per pollutant according to type of process facility on 1997 US dollars. Air emissions contain mostly methane as the biggest potential problem ($8.8-$59.5 per ton), cause of the greenhouse effect. If methane is flaring it turns into Carbon dioxide reducing the landfill effect ($2.1-$6.9 per ton), but the cost of carbon dioxide increase (from $0.4-$1.4 per ton to $0.7-$2.0 per ton). The authors also estimate the external cost per ton of vinyl-chloride ($4.3-$4.8 per ton), benzene ($0.1-$2.8 per ton) and other gases($0.3-$4.8 per ton). Water emissions are mostly compound by leachate's environmental cost. Leachate is generated from the interaction between degrading landfill material and water from precipitation, containing toxins that may contaminate groundwater. Because some controls the range is small ($0.0-$1.0 per ton).

Benzene costs, Emission costs and Leachate costs are related with the population ranking[3], the temperature ranking and the precipitation ranking respectly. The calculation is made using the following formula:

$$C_p = ((r_i - 1)/(n - 1)) * h_p + (1 - ((r_i - 1)/(n - 1))) * l_p$$

where C_p is pollutant cost, r_i is provincial ranking, n is the total number of provinces, and h_p and l_p are the high and low bounds of the respective environmental cost ranges from Miranda and Hale (1999). Adding these three costs and updating them with the CPI Inflation from the US Bureau of Labor Statistics, since original costs are estimated for US facilities, it is possible to obtain the Total External cost in US dollars from 2010.

Although the country presents two areas, one mild and one arid, I assume that the environmental cost is not affected by this distinction.

In order to calculate the total social cost, the internal cost of each province is required.[4] However, there is no available data on Argentina about tipping fees. Then, unit cost of disposal is used instead from

[2] Sadly there is no available information about the exact magnitudes

[3] Fullerton (2005) states that the best way to ranking the states by its benzene cost is using the population density, however, he prefers the population ranking because it's better to show the total potential cost of liberating one unit of benzene. It is also noted that it could exist waste exports between states.

[4] Internal costs are measured by Fullerton (2005) with tipping fees since Miranda and Hale (1999) shows that tipping fees are a good proxy of the internal disposal cost.

EVAL2010.

EVAL2010 is the Regional Evaluation on Urban Solid Waste Management for Latin America and the Caribbean elaborated by the Inter-American Development Bank in cooperation with the Health Panamerican Organization (OPS) and the Iter-American Association Environmental and Sanitary Engineering (AIDIS). It takes a stratified random sample of surveys on different levels based on National Statistics, classifying regions by socioeconomic and geographical characteristics and population sizes.

Since the information does not match completely, there are two alternative measures of waste volumes, the first one uses per capita generation volumes of municipal solid waste for regions provided by EVAL 2010, while the second one uses the per capita generation of each province from ENGIRSU.

ENGIRSU is the National Strategy to Integrated Urban Solid Waste Management elaborated by Secretary of Environment and Sustainable Development of the Ministry of Health and Environment on 2005. Due to the unavailability of data, and that the data available came from a lot of different sources, to elaborate ENGIRSU a survey had been made through visits and interviews to municipal staff by Deloitte and Touche Environmental S.A. between August 2004 and February 2005. This survey was carried out on 19 provinces, visiting 83 municipalities, excluding those that are management by CEAMSE and those from provinces like Cordoba, Entre Ríos, La Rioja and Mendoza, because there where specific studies for those provinces. The sample had 376 municipalities and covered a population of 12.6 millions of people.

Using these data I was able to project the correspondent municipal solid waste volumes for the population presented on each province. It is worth mentioning that both per capita generation volumes had been calculated from collected waste volumes and it may not reflect the real waste generation.

Taking prices previously calculated and using both alternatives to measure waste volumes of 2010, it is possible to compute the total potential revenue.

2.2 Results

As Fullerton (2005) states, this calculation must not be taken very seriously, nevertheless, some conclusions can be made.

First, Table 2 shows the Total External cost of one ton of waste disposed per province. It is surprising to notice that Buenos Aires is not the province with the highest Total External Cost, but Misiones is. This is due to the fact that Misiones has both the highest precipitation levels and one of the highest temperatures. It is followed closely by Chaco and Corrientes, also because of temperature and precipitation levels.

The province with the smallest Total external Cost is Tierra del Fuego, since it has the smallest population and the coldest temperatures. Close are two of other Patagonian provinces, Santa Cruz and Chubut with low scores on all three rankings.

INSERT TABLE 2 HERE

Next, Table 3 shows the Total Social Cost per Ton of Solid Waste per type of facility. Methane flaring facilities have their own range of emissions, so their external cost is quite smaller compared to the old non flaring facilities. This is observed not only on the per ton costs but also on the per bag cost, because the minimum total cost of non flaring disposal is almost the same as the maximum total cost on disposals with methane flaring.

Here can be seen that the provinces with highest social costs are Misiones and Corrientes, because its high Total External cost, and Entre Rios, because its Tipping fee.

Tierra del Fuego and Santa Cruz are the provinces with smallest optimal tax, because its low Total External Cost, followed by Rio Negro and Chubut.

INSERT TABLE 3 HERE

Taking into account that these calculations work only as a reference and they should not be understood as a rigorous solution, the results are a good estimation of how should vary the price per bag of waste between provinces, since it provides an approximation of the range of prices that could be taxed for the bag of garbage. Each province should tax only one price depending on the disposal method it uses. Had garbage imports exist, it would be necessary that each waste import province collect an extra tax to cover the landfill expenses and the external cost. If only one of the provinces collected the tax, the changes on import flows may affect revenues calculations.

Finally tables 4 and 5 show the Total Potential Revenues of applying an optimal tax.

INSERT TABLES 4 AND 5 HERE

Again, it should be remarked that on the total potential revenue calculations of each province, it is assumed that the provinces are not taxing garbage generation. In the case they are, the tariff per bag would cover the landfill expenditures and reduce household taxes or any other source of revenue used to pay its expenses.

Later on, it will be shown that the actual revenue that can be taxed by the optimum tax on waste is the same either using a pigouvian tax or a deposit-refund system. Clearly, the introduction one of them would represent an important source of revenues to national, provincial and local governments, which makes them attractive as fund raising.

Note that most of the revenues must be oriented to pay the direct cost of landfill disposal. The revenues that come from the external cost should not be redistributed among the population, government could use these incomes for solid waste programs or another type of programs. The part of the price that corresponds to the external cost would be a very important source of revenue in order to start new projects that would improve the management and the treatment of solid waste on a municipal level.

3 Theoretical Framework for implementation discussion

As stated in the Introduction, this paper is based on a general equilibrium model proposed by Fullerton and Kinnaman (1995) , which analyze one jurisdiction with n household that choose between leisure (h) and consumption (c). Consumption is determined by a mass-balance equation, $c = c(g, r, b)$[5], where individuals states levels of reciclying r, generating garbage g and dumping or burning b. Utility function of individuals is negatively affected by three externalities: the aggregate production of garbage $G = ng$, dumping $B = nb$ and the use of virgin materials $V = nv$

$$u = u[c(g, r, b), h, G, B, V]$$

It must be noticed that the loss of utility as a consequence of more illegal dumping is greater than the one produced by sanitary landfill, $\partial u/\partial B \equiv u_B \leq u_G \equiv \partial u/\partial G$

[5] $c(g, r, b)$ is a continuous and quasiconcave function

The production of consumption goods depends on labour or other resources, $c = f(k_c, r, v)$, and other production functions are characterized by $h = k_h$ for leisure, $g = \gamma k_g$ for garbage disposed on landfills, $v = \alpha k_v$ for virgin materials and $k_b = \beta(b)$ with $\beta_b > 0$ and $\beta_{bb} > 0$ for the production of illegal dumping or burning.

Social planer (government) budget constrain is given by the equivalence between all the labour employed on the economy ($k = k_c + k_g + k_h + k_v + k_b$)

In a competitive equilibrium individuals maximize their utility function subject to their budget constrain, $p_k k = (p_c + t_c)c(g, r) + (p_g + t_g)g + (p_r + t_r)r + p_k k_h + p_k \beta(b)$, where each p is a price, and each t is a tax rate. If consumers are paid by a private firm for recycled materials, the price p may be negative, and tax rates might be positive or negative. $p_c = 1$ since it's the numeraire good. The producers also maximize their benefits when their marginal product is equal to their marginal cost.

Without illegal dumping or use of virgin materials, marginal utilities of both producer and household incomes are equal in equilibrium. Had it not existed consume and recycling taxes ($t_c = t_r = 0$), taxes to garbage disposal on sanitary landfills would depend on the desutility that the externality generates: $t_g = -nu_G/\lambda$ where λ is the marginal utility of income at the optimum. Since u_G is negative, this tax rate is positive. The same happens when there are no externalities due to illegal dumping ($u_B = 0$).

If taxing illegal activities is impossible to collect or control ($t_b = 0$), the model propose a Deposit-Refund system characterized by the following equations:

$$t_c = nu_B/\lambda c_b > 0$$

$$t_r = nu_B c_r/\lambda c_b < 0$$

$$t_g = n(u_B c_g - u_G c_b)/\lambda c_b$$

$$t_v = -nu_V/\lambda$$

The main idea is to collect an excise tax as deposit and to give a subsidy to recycling as refund.

Due to the assumption that states that improper disposal must be more socially damaging that proper disposal, taxes to garbage generation (t_g) are negative. Proper disposal is then subsidized to avoid illegal dumping. If the subsidy is the same as the collection costs the city can avoid administrative costs by providing the collection free of charge.

The Deposit-Refund System presented is easy to implement because it does not depend on penalties to achieve a first-order solution.

If all disposal methods can be taxed, the equivalent tax system would consist on a downflow tax over garbage that require null consume and reciclying taxes ($t_c = t_r = 0$):

$$t_g = -nu_G/\lambda$$

$$t_v = -nu_V/\lambda$$

$$t_b = -nu_B/\lambda$$

Clearly, this system can solve the problem theoretically, since the tax of each activity reflects its own externality. Moreover, all the taxes are positive, and it is implied that $t_b > t_g$. However, t_b requires more enforcement mechanisms since the penalties are applied to actions that are easy to hide.

The tax on virgin materials does not correct garbage externalities because recycling can be subsidized directly. In this sense, taxing virgin materials encourages not only the use of recycling materials, but

also the labour and other resources that are inputs of the production function.

Given that some of the goods are more toxic than others, Fullerton and Kinnaman (1995) propose to state i categories by type of consumption goods according with their toxicity. Thus, the production function is $c = f_i(k_{ci}, r_i, v_i)$ and the disposal function is $c_i(g_i, r_i, b_i)$. In absence of taxing on illegal activities, the Deposit-Refund System is characterized by:

$$t_{ci} = nu_{Bi}/\lambda c_{bi}$$

$$t_{ri} = nu_{Bi}c_{ri}/\lambda c_{bi}$$

$$t_{gi} = n(u_{Bi}c_{gi} - u_{Gi}c_{bi})/\lambda c_{bi}$$

$$t_v = -nu_V/\lambda$$

To achieve the efficient allocation, consumers give the deposit in advance equal to the social marginal cost of improperly dispose the good, and through recycling they receive the refund, equal to the difference between the deposit and the marginal external costs of recycling the same good. If the last one is null, then, the deposit would be equal to its refund. In this sense, the Deposit-Refund System gives the required incentives to modify individual behavior using carrot and sticks approach.

As the social costs are different among the types of goods, Fullerton (2005) propose using an excise tax and subsidy vector, one component for each good. However this policy option is much more difficult to administrate than the Deposit-Refund system. Indeed, in absence of transaction costs, the refund could be given to households that recycle or to producers that use recycled materials. If refund is given to households, then a supply increase could move downward prices that the firms pay. However, if the refund is given to the producer, they will increase demand of recycled goods and raising the price that household receives.

To decrease administrative costs, a subsidy per ton or kg. of recycling material could be implemented instead of the units that the household produce. Another alternative is applying a Deposit-Refund system, but with an uniform tax for all types of goods this could be inefficient (several individual amounts could be far away from the optimum ones).

In the absence of this system, and with a waste generation tax, a welfare loss is produced due to improper disposal, exceeding any welfare gain of the waste generation tax.

Fullerton (2005) also evaluates applying a Deposit-Refund System locally, by state or municipality. This is possible because United States has a tributary system according to Fiscal Federalism, where the states can levy taxes with mobile base (as to local sales).

Between the advantages of a Deposit-Refund system, it can be mentioned that the refund properly encourages the firms to design products that are easy to recycle, while the households demand these products to receive the refund. In this sense, it can be optimally reduced not only the amount but also the toxicity of waste. Moreover, the system solves the problem of improper disposal, since the taxation comes before the purchase of the good.

Among the difficulties that this model presents, in its original version the authors remark the issue of population density, since applying control mechanisms and penalties to illegal dumping and burning on places with greater population density is more expensive. Another missing aspect is a spillover that may justify the use of an excise tax applied to producers on the national level can cross national borders, or can be affected by distributive issues. Second, recycled goods could be more than what national producers can absorb. However, none of this alters the implications of the model.

It is worth mentioning that Garriga (2011) uses this model to include the possibility to export waste, lead-

ing to the conclusion that if the state subsidizes waste, making export price smaller than the equilibrium, recycling and garbage disposal on sanitary landfill on the jurisdiction will decrease, while export to other jurisdictions will increase. In order for individuals to perceive that the total costs of their actions and prices were efficient, transport costs of waste must not be subsidized, or there must exist restriction to export waste.

4 Implementation Issues

4.1 General

The application of a local deposit refund system requires the existence of a tax system based on the correspondence principle. In Argentina, unlike the United States, the tax system has decentralization of expenditure but centralization of collection.[6] Moreover, expenditure decentralization has not prioritized achieving greater allocative efficiency nor respond to fiscal federalism theory, but its only goal had been to reduce the national government deficit. Therefore, the provinces have only faculties on immobile tax bases, such as property and automobile taxes, and they cover their deficit with a transfer system that does not reward their tax effort. *Ingresos Brutos* is the only sales tax that provinces have, which is based on the monetary value of sales and not on the amount of units sold.

Since provinces do not have the power to tax the consumption of specific goods, deposit fund raising would be a national government responsibility, which involves several disadvantages. First, the provinces are owners of the natural resources[7] and they are in charge of ensuring the environmental recomposition in case of any damage[8], so they should be the beneficiaries of the revenue. Nowadays, the provinces receive part of the collection made âĂŃâĂŃby the national government through sharing transfers. However, sharing criteria is not related with the amount of goods consumed and disposed on each province, a fundamental measure to determine the environmental damage and therefore the percentage of total revenue that should correspond to each province.

Second, the marginal social cost of disposal is not an immutable fact, even for a particular good with a particular toxicity. It depends on where the garbage is disposed, the nature of the landfill or another disposal place. In addition, had the country's landfills comply with the same rules on the treatment of waste, climatic differences would give different social costs. However, taxing goods according to the destination principle, setting different rates depending on the province, would generate inter-jurisdictional conflicts, leading to a possible arbitrage.

In the theoretical model, the refund involves the absence of transaction costs, but in Argentine, there are two actors involved on the recycling process, "*segregadores urbanos*", also called *cartoneros*, and intermediaries. Had the firms receive the refund, the price increase could be completely absorbed by intermediaries who would rise their markup. Another possibility could be that a recyclable materials' price rising would be perceived by *cartoneros* as an increase on their income, improving their life quality, but that in turn leads to an increase in the number of informal workers.

Alternatively to the deposit refund system, the model by Fullerton and Kinnaman (1995) shows that applying unit pricing to waste generation is only optimal when it is possible taxing improper disposal. This requires control mechanisms that the municipal governments of Argentine does not have, and

[6] Rotsztein: ""Fiscal Federalism and Provincial Sharing

[7] Articles 121 and 124 National Constitution.

[8] Article 41 National Constitution states the population rights of enjoying a healthy environment and the obligation to rebuild it in case of damage.

would be very expensive to maintain.

4.2 Gran Buenos Aires and Buenos Aires City

This section discusses the potential implementation of the two policies already mentioned (unit pricing and deposit-refund system) in the Metropolitan Area of Buenos Aires.

The first part of the section summarize the waste problem on the region regarding the available information presented on different documents, as “Diagnostic about the current situation of generation, recovery and final disposition of urban solid waste on Buenos Aires city"[9] and “Annual Dossier about integral urban solid waste managment of Law n°1,854"[10] and “Quality Study on Urban Solid Waste on Buenos Aires Metropolitan Area"[11] ,version 2010/2011, that presents the last available information about urban solid waste managment.

The city is relatively advanced on the legislative aspect in terms of the problem of solid waste management. In 2003, act n°2,225 was approved to recover and eliminate open dumps, *cartoneros*' activity was formalized[12] and Villa Dominico landfill was enabled to receive waste generated by the City. [13] In 2005, the City Legislature ratified the so called Zero Waste Act[14] and also the resolutions[15] determining domiciliary waste separation for the denominated Large generators.[16].

Zero Waste Act of Buenos Aires City seeks to preserve human health and the environment by promoting awareness of the population. With this purpose, Article n°6 sets a schedule to gradually reduce solid waste final disposal, which involves quantities reduction of landfills disposed waste. Goals forecast a 30% reduction by 2010, 50% by 2012 and 75% by 2017, based on the levels of waste sent to CEAMSE in 2004. This will totally prohibit disposal of both recyclable and reusable materials by 2020.

Since the publication of this act, combustion of waste in all its forms (with or without energy recovery) is banned. Making agreements about municipal solid waste generated in the city with firms that used combustion in other jurisdictions is not allowed.

To meet these objectives, the act states that the City Government will promote the reduction of waste generation and usage of more durable or reusable products, separation, recycling and composting and / or product biodigestion. It also promotes policies oriented to gradual replacement of packaging that is disposable for one that can be returnable, and separation of packaging to be collected separately at own expense of companies that use them. However, it's on government authority's discretion the decision of how these actions will be carried out.

Although Articles 14 and 15 of the Act establish that generators are responsible for performing separation and adopt measures to reduce the amount of municipal solid waste, and producers must bear the cost of collection and safe disposal of those packaging that can not be reused, recycled or composted, extending the responsibility until final disposal, it does not provide control mechanisms or incentives to make that happen.

[9] GCBA. permanent advising council, Law n°n°123. Monitoring commission of Law n°1854 of Integral Urban Solid Waste Management of Buenos Aires city.Sub commission of treatment and final disposal. (2007)

[10] GCBA. Ministry of Environment and Public Space(2008)

[11] Institute of Sanitary Engineering. Engineering Faculty - UBA (2011)

[12] Law n°992/03, Reglamentary Act n°622/03 and its update with Act n°422/04 Resolution n°71/06

[13] Resolution n°56/03

[14] Law n°1,854/05 and Reglamentary Act no 639/07

[15] Resolutions n°50/05, 640/07 and 808/07

[16] Hotels with four and five stars, public buildings from City government -administrative-, Madero corporation buildings, and horizontal property buildings which a high of more than 19 floors.

Moreover, in chapter V the Act states that people should dispose waste on public streets to minimize the negative effects on health and the environment. But leaving waste on public places turn it into a non-exclusive bad, making it difficult to control and / or to penalize.

Articles 19 and 20 of Zero Waste Act establish, that collection will be differentiated by type of waste in terms of their treatment and subsequent valuation, being City Government responsibility to ensure the provision of special containers in public places and government agencies of the City. Law also states that the frequency of collection must be different whether the waste is dry or wet, established by the enforcement authority. All personnel involved in waste collection must count with proper tools to protect their safety and sanitation. Wet waste collection must be done with closed body vehicles that reduce the volume and do not allow spillage of liquids, or residues fall outside the vehicle during transport.

The Act also defines that final disposal of urban solid waste is done with landfill technique that do not cause damage to the environment, public health or safety, using engineering principles to confine the waste in the least possible surface, reducing its volume to the minimum practicable, prohibiting open dumps garbage disposal, micro landfills creations, as well as watercourses disposal or incomplete burial.

The Act proposes to conduct advertising to clarify information and promote the purchase of recyclable and reusable goods, seeking to generate a change in population's behavior.

Zero Waste Act also highlights the inclusion of *cartoneros* in the formal circuit and promotes lines of credit and subsidies to cooperative firms registered in the REPyME in order to buy capital goods.

Some violations are mentioned, for example leaving waste on the streets outside the allowed time, or leaving it on containers that do not comply the regulations, not making separation. A violation of the Law of Integrated Urban Solid Waste Management is likely to be punished with a fine of $ 50 to $ 500. If the offense is committed by a *Gran Generador*, the owner is responsible and will be punished with a fine of $ 200 to $ 5.000 and / or disable and / or closure. It is also mandatory to put waste in biodegradable bags. However, the law does not state how to perform control tasks, typical of police power exercised by the state.

In the year 2006, and with the same purpose, the Responsible urban solid waste management Program[17] was created. Then, in 2007 urban recyclers' records and Cooperative firms were organized, approving the "Procedure Manual for the urban recyclers Program ", the ID credentials and registration regulations in the "REPyME".[18]

On the other hand, from 1978 the province of Buenos Aires has regulations on how to dispose garbage in the jurisdictions of the Metropolitan Area[19] through the CEAMSE[20]. In 2002, the law was expanded to include all other municipalities and to unify information by creating the Provincial Records of Collection Technologies, Treatment, Transportation and Final Disposal of Urban Solid Waste.[21]

In that same year, minimum precautions were regulated to start working with disposal facilities[22], added to those already stated by the Law nº9.111/78.

Regarding the National Strategy, the Province of Buenos Aires impulsed the Integral Urban Solid Waste Management through Law nº13.592/06 and Regulatory Act nº1.215/10 where management procedures were stated according with the law of minimum budgets. There was established that municipalities

[17] Resolutions nº191/06 and 746/07

[18] Resolutions nº753/07 and 803/07

[19] Vicente Lopez, San Isidro, San Fernando, Tigre, General Sarmiento, General San Martin, Tres de Febrero , moron, Merlo, Moreno, La Matanza, Esteban EcheverrÃ■a, Almirante Brown, Lomas de Zamora, Quilmes, Avellaneda, LanÃžs, Florencio Varela, Berazategui, Berisso, Ensenada and La Plata.

[20] Law nº9.111/78

[21] Law nº1.142/02

[22] Law nº13.657/07

must develop projects of integral waste management that incorporate gradually 4R principles, setting progressive goals on reduction of final disposal of urban solid waste.

Institutionally, different legal organisms coexist. On one hand, the Ecological Coordination Metropolitan Area Society of the State (hereinafter CEAMSE), defined as the Competent Authority by Act 9.111/78 and the respective Accession Laws of the City, establishing the role of the City as a member of this society and responsible with the Province of Buenos Aires for the management referred to in Articles 32, 38 and 51. On the other hand, the Ministry of Environment and Public Space of the City Government is the authority mentioned in Law N°1854, Articles 32, 34, 38 and 51, which should make inter-jurisdictional agreements to implement regional strategies for waste disposal, ensuring that the companies operating landfills comply with the National Law on Minimum Standards of Residential Waste Management N°25,916. In addition, the companies must present a management plan to the Administration, including operations, monitoring, closure and post-closure maintenance. In the province, that role is fulfilled by the Provincial Agency for Sustainable Development.

Regarding financial aspects, none of the official documents presents the private costs of waste disposal or how the jurisdiction get the revenue required to pay them.

On the city, the funding is based on a fixed tax(named Lighting, Scavenging and Cleaning or ABL), which is taxed by house property, according to its dimensions. This tax does not reflect the environmental costs of waste generation and disposal. It does not contemplates garbage value, since it could be reused as an industrial input. Consequently, the fixed tax does not generates the incentives required to accomplish the goals stated by the Law, which in turn develops on a deficient waste management. Moreover, the incidence of the tax on the total revenue of the city had been falling year after year.

In 2010, the revenues from ABL ($1,365.4 millions) did not cover the 70% of the assigned budget of the Environmental and Public Space Ministry of the city that was $2,149 millions. It barely was sufficient to cover the collection costs (approximately of $1,000 millions). This cost raised on the last years due to sequential extensions of the contracts. On 2012, the amount paid for collection by the city was $1,678 millions.

According with data estimated by deputy Martin Haurest, the city of Buenos Aires spent $1,761 millions in 2011 and $1,873 millions in 2012.

It must be considered that evaluation and payment by collection are made by clean area and not by ton of waste collected. It was expected that this would have brought improvements to efficiency levels of waste managment, however, it had not happened.

Besides of collection, Buenos Aires must pay by final disposal of waste that goes to landfills.

On an interview to Accountant Armando Schiavi, Finance Manager of CEAMSE, he remarked that municipal and private tipping fees are under their equilibrium level. According to the talking, private tipping fees are a better approximation of the costs, but they only affect a small part of the volume disposed(less than 10%). Municipal tipping fees, unlike the private ones, are subsidized and in most cases the municipality has part of sharing funds.

Tipping fees had remained constant since 2009 to 2011, having increased 90% on February 2012. According to the Environmental and Public Space Ministry of the city, Buenos Aires pays u$s 50 per ton, while province jurisdictions pay less than half of that.[23]. It must be noticed that tipping fee set by CEAMSE is the same for both the city and province jurisdictions, but the latter count with sharing funds to pay it.

Due to the recent conflict between the province and the city, CEAMSE decided to raise tipping fees

[23] Videla (2012)

35% to the city because its non compliance with the goals stated by Zero Waste Act. Regarding the coverage, National Population and Household Census 2010 does not presents information like previous census did. However, in 2001 most of the jurisdictions had a coverage of 90%

The Sanitary Engineering Institute of Buenos Aires University, in coordination with CEAMSE, compiles waste generation data from waste already collected, on transfer stations and final disposal places, without taking into account what is recover through the informal circuit.

Figure 1 presents the evolution of urban solid waste generated on the period 1996-2012.

INSERT FIGURE 1 HERE

It is observed that 2002 presents the smallest volumes of generated waste, which can be explained because of the activity collapse produced by the economic crisis on 2001.

Surprisingly, since the approval of Zero Waste Act on 2005, the volumes of waste had not decreased, but increased on a greater rate compared with the *Conurbano* cases.

It must be noticed that this information presents a distinction between total waste volumes (reflected on the figure) and those correspondent to domiciliar waste, scavenging and others. This is due to the fact that in Buenos Aires case total waste volumes includes a big proportion of construction waste.

The rise of public and private constructions and the entrance of materials from the province[24] were some of the motives of the increasing on construction waste volumes disposed by the city

Table 1 presents values of per capita generation and total generation of urban solid waste on 2010. This data was obtained from volumes of waste collected.

INSERT TABLE 1 HERE

Buenos Aires city per capita generation of waste in 2010, without taking into account the construction waste, was 1.35 Kg/hab/day, less than in 2004 (1.52 Kg/hab/day according to the National Strategy) and also to the amount estimated by EVAL 2010 for that year(1.41 Kg/hab/day). If construction waste is considered, per capita generation of waste rises to 2 Kg/hab/day.

In Gran Buenos Aires, per capita generation of waste is smaller than the one from the city. This can be explained by several motives: first, the highest level of income of the city population; second, a huge part of the people of the 24 jurisdiction of Gran Buenos Aires spend most of their life on the city, generating waste there. Nevertheless, almost one third of the jurisdictions presents values above 1 Kg/hab/day. Even two of the highest income level population jurisdictions, such as Vicente Lopez and San Isidro, exceed the levels of Buenos Aires city.

Considering the complete Metropolitan Area, the city and 33 jurisdictions from the province, it can be noticed that per capita generation value is lower than 0.5 kg/hab/day. This is due to the fact that calculations are made based on collected amounts of waste, without considering burning and improper disposal, common practices on the region.

Regarding the characterization of waste, the Quality Study on Urban Solid Waste (ECRSU) 2010 / 2011 states that food waste predominates (41.55%), followed by plastics (18.54%), papers and cartons (16.64%), garden waste (6.03%), textile materials (4.59%) and glass (3.09%). These types of garbage can be recycled or reused if they receive the proper treatments. This is a huge opportunity in terms of reduction of waste disposed on landfill.

[24] (allowed by agreement on november 2007)

On the Metropolitan Area, the recycling is made mostly by the informal sector.

In 2005, in order to implement Zero Waste Act, the city government signed Urban Sanitation contracts with collection firms, dividing the city into six areas[25], until the construction of a Green Center in each area. Even though the contracts had a duration of 4 years, with the possibility to extend it 1 year more, they had been extended repeatedly due to failures in the licitation processes made by the city government on the last years.

The division determined the plotting of the routes and the installation on 25% of the city of a double contenerization: for “recyclable goods", such as dry clean papers and cartons, plastics, glasses, metals, textiles; and for “garbage", as food waste, styrofoam, ceramic, dirty paper and cartons. Then, two collection system coexist for recyclable materials, one formal and one informal.

It seems that the issue has not been taken very seriously. The city government tried to encourage separation several times[26],with propaganda to generate population awareness, but it did not accomplish the desired results.

Last available numbers about recycled materials are from the “Anual dosier of Urban Solid Waste Management" (2008). In 2007, the formal circuit recycled 280 tons and receive from the government $54 millions, i.e. 193,000 $/ton while its marked price was about 400$/ton. This discrepancy was the reason why the city government rejected the contenerization programs in the following years, delaying the goals proposed by Zero Waste Act.

Just at the end of 2011, minister Diego Santilly announced that contenerization policies would restart, with goals of 100% of wet waste and 77% of dry waste. In this sense, the city would have two containers per block by the end of 2012. According to official data, the government estimated that the formal circuit recycle 16 tons per day.[27]

In terms of the informal circuit, several estimations had been made in 2007 and 2008, which account for different flows of waste recovered.

The first estimation was made by the Engineering Faculty of Buenos Aires University. In 2007, *cartoneros* recovered between 290 and 350 tons of domiciliar solid waste per day. This represented between 11 and 13% of total domiciliar waste (2,678 tons, according to the same source)

The second estimation, made by the General Agency of Urban Recycling Policies, was focused on the transit of recyclable materials from the city to the *Conurbano*. It must be noticed that three obtaining and recovering ways were analyzed. The first one is called Curbside collection service and affects only Large generators by Resolution no. 50 of the Environmental Ministry of the city. There is no available information about this service at the moment. The second one is related with *cartoneros*' activity, first link of the informal circuit, that provides recycled materials as inputs for the industries. However, between the *cartoneros* and the industries there are several intermediaries, which generates different channels where collected materials flow. The materials recovered by *cartoneros* presented three ways out of the city: trucks called freight and scales, minor collection deposits and mayor deposits, apart from different services of trains of *cartoneros*. The third way of recovery consisted of Special Programs in charge of the civil population[28]

The study showed that the amount of waste recovered by the informal circuit on Buenos Aires city was 600 ton/day, 11% of the total amount of domiciliary waste generated plus scavenging and others.

The studies calculated the percentage of waste recovered on different basis, the first used domiciliary

[25]The companies in charge were CLIBA, AESA, URBASUR, NITTIDA, INTEGRA, and Urban Sanitation Entity

[26]February 2005, May 2006, December 2007, February and April 2008.

[27]GÃşmez (2012)

[28]Like the one from 1999 to 2006 organized by the Fundaci'on Garraham.

and the second total amount of waste. For future estimations, it should be necessary a unified criteria.

A recent work estimated that in 2012, the informal circuit recycle 10% of the waste. [29]

Regarding the recycling of organic waste, once processed, last data from 2007 indicates that it was delivered free-of-charge to jurisdictions of Metropolitan Area upon request.

It must be noticed that these alternatives of collection coexist with others that do not involve recycling, based on reuse and restore of articles in disuse, that could have been gone to final disposal. Some of the examples are the Salvation Army, church collections, flee markets, activities like the promoted by the Fundación Equity to restoration and donation of computers, among others. Most of these programs are still active. The city government considers that these programs work properly, so there is no need to do a survey about them.

A key measure was taken on 2008, when city government requested that separation and valuation were included among the tasks of CEAMSE. With this purpose, Green Centers were installed [30], including among the formal circuit 11,500 tons.

In the last years, several agencies started projects in order to reuse construction and compostable waste. At the same time, a single permanent mandatory record of *cartoneros* was created, providing *cartoneros* with proper tools and work materials.

The last stage involved on municipal solid waste management, final disposal, is an matter of conflict through the region.

On a provincial level, the situation is much more complex. There are more than 50 jurisdictions participating of the program “your block recycles"[31], and some programs as “3Rs" and a program to recover alimentary oil have been implemented on some jurisdictions. However, they had been not enough, so there are no progresses on the implementation of the law.

According to official data, the amounts of waste disposed exceed the ones predicted by the Zero waste Act by almost 36%. If the grow rate remained the same in 2012, the amount disposed would be approximately 84% more that the stated by the law.

Figure 2 presents the evolution of the total amounts of waste disposed on the Metropolitan Area by landfills.

INSERT FIGURE 2 HERE

On a provincial level, funds have been delivered to some jurisdictions according to the Provincial Program of Municipal Solid Waste. The main objective of this program was to assist on the design of some provincial policies about the treatment and final disposal of municipal solid waste, coordinating the jurisdictional enforcement. The aim for the first ring was to build Treatment Facilities where each treated a fifth part of MSW generated by the city and the jurisdiction where the facility is placed, with an operative capacity of 2000 tons/day. Regarding the other jurisdiction of the Metropolitan Area and the rest of the province. The program proposed to build a treatment facility on each jurisdiction according with the amount of waste generated, taking into account the possibility to make inter-jurisdictional agreements between neighboring jurisdictions. At the present, there is no available information about the progress of this program.

[29] Gómez (2012)

[30] Centro Verde managed by CLIBA, Centro Verde managed by NITIDA, Centro Verde Villa Soldati, Centro Verde Bajo Flores, Centro Verde Retiro Norte y el Centro Verde Polo de Microemprendimiento (Ex. Usina)

[31] Suplemento ámbito municipal (2011)

However, the province is evaluating the treatment of its own waste. On november of 2011, the Governor of the province signed an agreement with the National Environmental Agency, the Agency Buenos Aires Invests and the jurisdictions of Florencio Varela and Berazategui to build two facilities financed by national government that would process 500 tons, promoting entrepreneurships of more than 300 *cartoneros*.[32]

In 2012, provincial legislature started evaluating a bill that bans waste import starting on january 2014 [33] and pushed the city government, through CEAMSE, to implement a program that in the term of 30 months would achieve the reduction of waste exported to the province in a 50%.

Note that the disposal centers of CEAMSE are not the only places where waste is disposed on the region. Regretfully, an undetermined number of open dumps exist, which are originated mostly because of the clandestine spill of waste to avoid paying transport costs and tipping fees. This waste is usually organic and comes from restaurants that pay to firms which collect waste after hours or it comes from construction through illegal firms of dumps.

In november 2007, city government and CEAMSE signed an agreement to give CEAMSE some property on the city to work as transfer facility of construction and garden waste, stating that CEAMSE would control the entry and exit of vehicles, install a scale and manage to obtain the environmental certificate. However, in mid-2008, the city government decided that the location was not convenient and signed an agreement with the provincial government where both committed to build two new landfills and two new transfer facilities that would be managed by CEAMSE. The agreement was unsuccessful due to the rejection of several communities to host the facilities.

According to official sources, in the last years the Provincial Agency to Sustainable Development (OPDS) closed more than 250 open dumps.[34]

The closure of open dumps has increased the disposed waste on CEAMSE landfills, contributing to their suffocation.

Finally, on May 2011 CEAMSE signed an agreement with the firm Arrow Latin America to build a treatment facility on Complejo Ambiental Norte II.

In order to discuss the implementation of these policies, two possible scenarios are presented, with and without inter-jurisdictional cooperation, together with their problems and proposed solutions.

One problem that arises with the implementation of unit pricing is related to the quantification of waste. The model assumes that it is possible to quantify waste generated and recycled by each household in order to apply the appropriate fee. However, the city of Buenos Aires has a large number of consortia, reflecting its high population density, which are not considered large or special generators because they do not comply the requirements.

Charging a unit pricing for waste generated by the consortia, equally shared by the apartments, does not provide correct incentives to waste reduction since equitable sharing of the tax within the consortia prevents each apartment to perceive the social cost of its own generated waste, which is the main objective of this type of policy.

In order to achieve efficient solid waste management, coordination of goals and objectives between agents is required. There are several stages in the waste management, such as generation, collection and separation, treatment and disposal, and regulation and control. Some of them present economies of scale, as collection and final disposal, which indicates the presence of a natural monopoly. However, the multiplicity of actors involved in both stages demonstrates the lack of economic criteria on waste

[32] Diario Hoy (2011)

[33] Gómez (2012)

[34] Suplemento Ãąmbito municipal (2011)

management.

International experience has shown that inter-municipal cooperation enables cost savings and leveraging economies of scale through the use of a shared landfill. However, as stated before, there must be inter-municipal and inter-sectorial coordination for joint decision making and the distribution of both initial investment and maintenance costs.

Another advantage of inter-municipal dialogue is that it can generate a change in public perception about waste management.

Both Article 125 of the National Constitution and Article 51 of the Zero Waste Act of Buenos Aires city, support the development of regional and provincial agreements that allow an improvement of waste management. The country presents many cases of inter-municipal coordination in Chubut, Mendoza, and La Pampa among others.

One of the most critical issues regarding coordination on the Metropolitan Area of Buenos Aires is the so called spillovers. The presence of spillovers in waste management due to daily entrance of people from the province of Buenos Aires to the city is offset by waste output (and the correspondent payment) the other way around.

To distinguish between the waste generated by the locals and that generated by the population of the suburbs who conducts most of its life in the city, two different estimations were made, with and without spillover. Buenos Aires per-capita generation data provided by EVAL 2010 was used in the total volume calculation for the spillover case. For those generated by the city in absence of spillovers, I used Montevideo city per-capita generation data provided by the same source.[35]

Table **??** presents the total volume estimations and the differences with the goals proposed by the law 1,854.

INSERT TABLE **??** HERE

In the absence of spillovers, the City of Buenos Aires would generate 23% more waste than those expected by the Zero Waste Act. Taking into account the spillover effect, which represents 200,000 tons of waste, failure was about 42%. This shows that the spillover effect may be huge in Buenos Aires.

To avoid such spillover problem, the metropolitan area could be considered as a continuum for waste treatment legislation purposes. The latter requires the creation of a common regulatory agency throughout the region that encourages an effective reduction of generated, collected and disposed waste.

Last year, a tripartite agency has been created to coordinate transport policies between the Nation, the Province and the City. This sets a precedent for the possibility of developing joint policies for the region.

The metropolitan area has already an inter-jurisdictional agency, the CEAMSE, which concentrates the entire waste disposal. However, it is a quasi private entity, that receives its payment per ton of disposed waste in the landfill, so it has no incentives to reduce the amounts of waste. To make CEAMSE the agency in charge of waste management coordination, it will be necessary to include among its functions the management of all stages involved in the process, making it responsible for the collection, separation and proper waste treatment, matching its income to the goals stated by the Zero Waste Act without taking into account the number of tons processed.

Yet, existing a coordination scenario and taking into account the previous discussion, the implementation of the deposit refund system as proposed by Fullerton (2005) requires to restructure the Argentine tax system. In the short term this seems quite unlikely to occur because national government does not have

[35] Both cities have the same environmental conditions, climate, type of soil, etc.

incentives to modify the law; despite that local governments may have, they need parliamentary majority which is difficult to accomplish. Nevertheless, an alternative proposal would involve to implement a nationwide set of excise taxes, sorted by type of product, similar to tobacco or fuel cases. In this sense, the revenue would be centralized and the tax could be applied either to the producer or to the final sale. However, the transfer of those revenues should be considered outside the sharing law, matching the ranking of environmental damage and the amounts of waste disposed on each province.

With the idea that the consumer receives the right incentives, it is necessary to fully incorporate informal workers in the formal circuit, so that their income does not depend on the tons of materials collected, getting rid of intermediaries, and applying the refund directly to households. The policies implemented in the recent years, such as the creation of Green Centers and cooperative firms participation in procurement calls, seem to go in that way. However, the income of cooperative firms still depend directly on the volume of materials collected. Once incorporated into the formal system, it is still undetermined how the household would perceive the refund. It could be implemented with a ticket that gives credit to purchase other goods or to pay other taxes.[36]

The inter-jurisdictional cooperation is jeopardized by politician incentives. The project under evaluation by the Legislature of the Province of Buenos Aires cited before, added to the fact that it had been ordered the closure of two of the three disposal centers and the third has an estimated lifespan of two years, pose Buenos Aires City on the edge of suffering from constriction.

To meet the goals set on Zero Waste Act, the city government must take urgent measures to reduce waste of all generators, being local or from the *Conurbano*.

Due to the lack of land and the strong opposition of neighbors, creating a landfill inside the city is completely unthinkable. Unable to export the waste to the Suburbs, the City will be forced to process waste to entirely reuse it, which suppose a paradigm shift from land disposing to processing. This transformation of waste management involves major investments that would only be paid by the population of the city. However, the city must give each waste generator the signals related with the environmental costs that they generate.

Implementing a deposit refund system in the area of âĂŃâĂŃBuenos Aires is not feasible given the current no-cooperation scenario. The city should obtain the power to levy taxes per unit of goods consumed, and *cartoneros* and intermediaries should stop being paid per ton of waste collected.

One possible answer would be to implement a system of two-part tariff, which involves a fixed charge for the service and a unit pricing, function of the amount of waste generated. However, such a system presents the difficulty of quantifying waste generated by each household, requires control mechanisms and improper disposal penalties. Despite the high administrative costs involved, the unit pricing would generate a reduction in waste to dispose in landfills (either because there is a change in the behavior of households and they consume a greater proportion of recyclable goods, or because they start disposing waste improperly outside the formal circuit).

Taking into account the previous analysis, different policy recommendations are proposed. In any case, the city government must agree to reduce the waste generated at least to levels without spillover, in order to achieve the goals of the Zero Waste Act. Among the policies, one possibility is to modify the ABL, taxing differently high income population. This policy would not be efficient, since it would not modify the behavior of households and therefore waste quantities would remain the same or continue to increase. Nonetheless, this would increase revenues that could be used to improve waste management.

Another possible policy would be to apply a two-part tariff as that mentioned before. In order to properly

[36] These policies must be followed by public diffusion through the media and the education system to increase the awareness and participation of the entire population.

quantify waste, it would be necessary to change the consortia regulations to force inhabitants weight their waste by type and present regularly their tickets to the consortia administration, which must conveniently locate scales to make the task easier. The consortia would pay the unit pricing and then would charge it on the apartment expenses according with the tickets presented to prevent fool play from neighbors. Had a difference between the collected and presented tickets amounts of waste appears, the consortia would apply penalties to this apartment. As already noted several times, this policy requires a series of control mechanisms and a system of penalties to reduce improper disposal.

Using the Quality Study on Municipal Solid Waste (ECRSU) to describe the waste collected in the city on 2010-2011, it can be seen that the food is 41.55% of the total waste. Moreover, considering garden waste, this percentage rise to 47.58%. Those materials are completely compostable on a treatment plant, but to make this possible there must be correct separation at the beginning of the chain, so the raw materials won't be contaminated with other toxic wet waste. Although the city government recently started containerization, this is intended to separate the solids from the wet waste, undermining the production of compost. However it doesn't seem very difficult to adapt this program to separate between organic and inorganic waste, it is only necessary to take into account a special treatment for those wet waste that are not compostable, like diapers and pads.

In addition to broadcast on the media and the education system, this program requires real incentives to separation. If *Cartoneros* joined the formal circuit, it could be conceivable implementing a subsidy to households for recyclable materials such as the refund on a deposit refund system. This policy must be implemented with regulations that systematically extend responsibility to the producers according to Article 15 of the Zero Waste Act.

Finally, to make the people from the *Conurbano* really perceive the the environmental cost of the waste they generate in the City, discrimination policy could be applied, taxing waste generation relative to net migration toward the city, by charging goods and services related to population entry (fixed places as parking lots, restaurants, etc..) such as Ramsey prices, with the appropriate discount for city residents.

5 Conclusions

This work attempts to provide an analysis of the critical situation of the region in terms of levels of waste generated and disposed. This suggests that the government must take urgent measures to avoid an environmental disaster.

Even though the situation is alarming, this is the moment to apply policies to improve municipal solid waste management. With this purpose, theoretical models had been presented in order to explain agents behavior and the impact that the policies have on it, given the required tools to evaluate market failure through quantification of total external costs.

Among the pricing policies, it is evident that fix taxes do not provide the proper incentives for individuals to reduce waste generation. For this reason, it is believed that unit pricing does produce the correct signals about the true cost of waste disposal. It is proved that this policy increase recycling and compost. However, in order for unit pricing to be effective, an institutional framework is required, with control mechanisms to quantify each household waste disposal and penalties to improper dumping. This is due to the fact that collection demand is inelastic, and the introduction of a unit pricing encourages improper waste and excessive compact when the tax base is waste volume.

For the purpose of this policy to be successful, it needs also educative campaigns and propaganda, as policies to eliminate improper dumping, such as a day of free disposal and the blocking of commercial dumps. Also, it is proposed using two part-tariffs to cover fix costs. Nevertheless, unit pricing is a

regressive policy that affects more low income households, taxing improper dumping is quite difficult, and control costs could be really high (specially on quite dense areas).

These are the reasons why a Deposit-Refund system is presented as a better policy than unit pricing, since it has lower implementation costs as it tax the correct pricing to each disposal alternative, avoiding taxing improper dumping and its correspondent evasion.

But the system comes from a theoretical model that assumes that central planer, the government, has complete and perfect information about the amount of waste generated and disposed, ignoring the transaction costs, and individual's costs in terms of time and risk of being caught. Moreover, the implementation of the system assumes an institutional framework where the government has the ability to tax any type of tariff. As the cost of waste disposal vary through regions, on the implementation of a Deposit-Refund System, taxes should also vary. However, tax differently on each region has new problems due to cheating and evasion.

Once the export option is incorporated, the model states that agents do not internalize the export decision, because the decision is made by the government while the population from other jurisdictions pay the costs. The methodology proposed to evaluate environmental damage is only valid if all the facilities has the same rules. It must be noticed that an important part of the external cost had been excluded, because aesthetic costs are difficult to quantify, while from the private costs only had been considered tipping fees, without considering collection, separation and process costs.

The theoretical analysis leads us to move forward on the search of overcome solutions to those proposed by the dominant paradigms. This work is a starting point to the design of policies intended to improve municipal solid waste management on the Metropolitan Area of Buenos Aires. It is expected that on a near future information gaps could be reduced, leading to a greater understanding of waste steams and subsequent quantitative assessments of the impact that policies generate.

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Table 1: The Ranking System Used for Local Pollutants

Column (1) contain the name of the province. Column (2) has a rank based on Census data 2010: the lowest population gets 1. Columns (4) and (6) have ranks based on averages of the decade 2001-2010 from the National Meteorological Service information. Column (3), (5) and (7) are expressed on 1997 US dollars, calculations are made according to the formula: $C_p = ((r_i - 1)/(n-1)) * h_p + (1 - ((r_i - 1)/(n-1))) * l_p$ where C_p is pollutant cost, r_i is provincial ranking from columns (2), (4) and (6), n is the total number of provinces, and h_p and l_p are the high and low bounds of the respective environmental cost ranges from Miranda and Hale (1999). Total External Cost is expressed on 2010 US dollars using the CPI inflation from the US Bureau of Labor Statistics.

Province	Population rank	Benzene cost	Temperature rank	Emissions cost	Precipitation rank	Leachate cost	Total External cost
(1)	(2)	(3)	(4)	(5)	(6)	(7)	
Buenos Aires	23	2.80	8	6.19	16	0.68	13.14
Catamarca	5	0.59	20	8.92	7	0.27	13.29
Chaco	15	1.82	21	9.15	19	0.82	16.01
Chubut	7	0.84	4	5.28	3	0.09	8.44
Cordoba	22	2.68	10	6.65	14	0.59	13.47
Corrientes	14	1.70	19	8.69	22	0.95	15.41
Entre Rios	18	2.19	12	7.10	20	0.86	13.79
Formosa	8	0.96	23	9.60	21	0.91	15.58
Jujuy	11	1.33	14	7.55	13	0.55	12.81
La Pampa	3	0.35	7	5.96	11	0.45	9.19
La Rioja	4	0.47	17	8.24	8	0.32	12.26
Mendoza	20	2.43	6	5.74	6	0.23	11.41
Misiones	16	1.94	22	9.37	23	1.00	16.73
Neuquen	9	1.08	5	5.51	2	0.05	9.02
Rio Negro	10	1.20	3	5.05	5	0.18	8.75
Salta	17	2.06	16	8.01	15	0.64	14.55
San Juan	12	1.45	11	6.87	1	0.00	11.31
San Luis	6	0.71	9	6.42	12	0.50	10.37
Santa Cruz	2	0.22	2	4.83	4	0.14	7.05
Santa Fe	21	2.55	13	7.33	18	0.77	14.48
Santiago del Estero	13	1.57	18	8.46	10	0.41	14.19
Tierra del Fuego	1	0.10	1	4.60	9	0.36	6.88
Tucuman	19	2.31	15	7.78	17	0.73	14.70

Table 2: Internal and External Costs per Ton of Solid Waste

Column (1) presents unit disposal cost from EVAL 2010. Column (2) has values from Table 2 . Columns (3) and (4) adds Columns (1) and (2) to the low and high end costs with non flaring, and Columns (5) and (6) do the same for flaring facilities . Columns (7), (8), (9) and (10) are a 10% of Columns (3), (4), (5) and (6), and represent the amount of the optimal tax per bag of waste disposed. All the amounts are 2010 US dollars

Province	Tipping fee per ton	Total local external cost	Cost per 32-gallon bag (145.5 liters)							
			No flaring		Flaring		No flaring		Flaring	
			Low-end total cost	High-end total cost	Low-end total cost	High-end total cost	Low-end total cost	High-end total cost	Low-end total cost	High-end total cost
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Buenos Aires	12.14	13.14	37.78	108.02	29.08	37.37	0.38	1.08	0.29	0.37
Catamarca	16.61	13.29	42.40	112.64	33.70	41.99	0.42	1.13	0.34	0.42
Chaco	16.61	16.01	45.12	115.36	36.42	44.71	0.45	1.15	0.36	0.45
Chubut	12.14	8.44	33.08	103.32	24.38	32.67	0.33	1.03	0.24	0.33
Cordoba	12.14	13.47	38.11	108.35	29.41	37.70	0.38	1.08	0.29	0.38
Corrientes	45.73	15.41	73.64	143.88	64.94	73.23	0.74	1.44	0.65	0.73
Entre Rios	45.73	13.79	72.02	142.26	63.32	71.61	0.72	1.42	0.63	0.72
Formosa	16.61	15.58	44.69	114.93	35.99	44.28	0.45	1.15	0.36	0.44
Jujuy	16.61	12.81	41.92	112.16	33.22	41.51	0.42	1.12	0.33	0.42
La Pampa	12.14	9.19	33.83	104.07	25.13	33.42	0.34	1.04	0.25	0.33
La Rioja	16.61	12.26	41.37	111.61	32.67	40.96	0.41	1.12	0.33	0.41
Mendoza	45.73	11.41	69.64	139.88	60.94	69.23	0.70	1.40	0.61	0.69
Misiones	45.73	16.73	74.96	145.20	66.26	74.55	0.75	1.45	0.66	0.75
Neuquen	12.14	9.02	33.66	103.90	24.96	33.25	0.34	1.04	0.25	0.33
Rio Negro	12.14	8.75	33.39	103.63	24.69	32.98	0.33	1.04	0.25	0.33
Salta	16.61	14.55	43.66	113.90	34.96	43.25	0.44	1.14	0.35	0.43
San Juan	45.73	11.31	69.54	139.78	60.84	69.13	0.70	1.40	0.61	0.69
San Luis	45.73	10.37	68.60	138.84	59.90	68.19	0.69	1.39	0.60	0.68
Santa Cruz	12.14	7.05	31.69	101.93	22.99	31.28	0.32	1.02	0.23	0.31
Santa Fe	12.14	14.48	39.12	109.36	30.42	38.71	0.39	1.09	0.30	0.39
Santiago del Estero	16.61	14.19	43.30	113.54	34.60	42.89	0.43	1.14	0.35	0.43
Tierra del Fuego	12.14	6.88	31.52	101.76	22.82	31.11	0.32	1.02	0.23	0.31
Tucuman	16.61	14.70	43.81	114.05	35.11	43.40	0.44	1.14	0.35	0.43
Argentina	22.46	12.30	47.25	117.49	38.55	46.84	0.47	1.17	0.39	0.47

Table 3: Total Potential Revenue: Volumes from ENGIRSU

Column(1) show volumes of waste from ENGIRSU. Columns (2),(4),(6) and (8) are the same total external costs from Table 3. Column (3)=Column(1)* Column(2), Column (5)=Column(1)* Column(4), Column (7)= Column (1)* Column(6) and Column(9)= Column(1)* Column(8). Columns (3),(5),(7)and (9) represent the potential net revenue of applying an optimal tax.

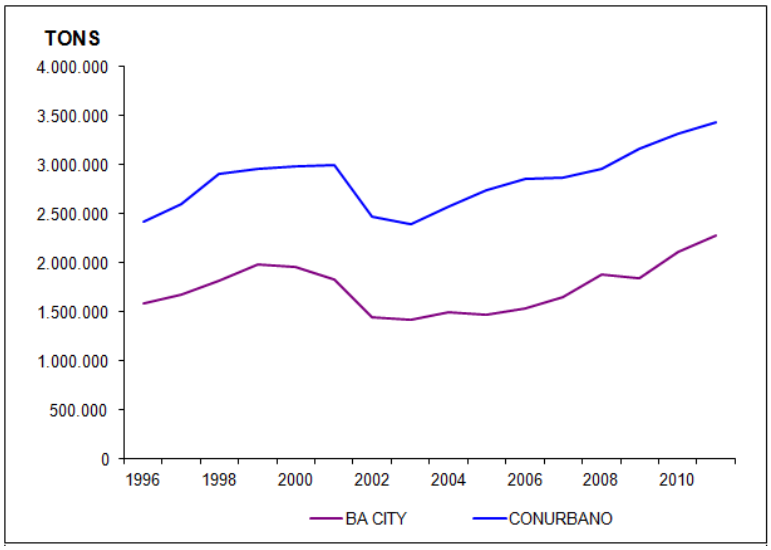
Province	Quantity	No flaring				Flaring			
	(tons/day)	Low end		High End					
		Total external cost/ton	Potential net revenue ($/day)	Total external cost/ton	Potential net revenue ($/day)	Total external cost/ton	Potential net revenue ($/day)	Total external cost/ton	Potential net revenue ($/day)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Buenos Aires	17,361.85	25.64	445,182.29	95.88	1,664,678.58	16.94	294,134.20	25.23	438,063.93
Catamarca	253.80	25.79	6,545.44	96.03	24,372.44	17.09	4,337.37	25.38	6,441.38
Chaco	643.71	28.51	18350.07	98.75	63,564.12	19.81	12,749.81	28.10	18,086.15
Chubut	483.65	20.94	10,125.60	91.18	44,097.36	12.24	5,917.83	20.53	9,927.31
Cordoba	3,474.32	25.97	90,223.60	96.21	334,259.82	17.27	59,997.02	25.56	88,799.13
Corrientes	863.56	27.91	24,100.00	98.15	84,756.29	19.21	16,587.05	27.50	23,745.94
Entre Rios	741.60	26.29	19,496.45	96.53	71,586.18	17.59	13,044.56	25.88	19,192.39
Formosa	344.61	28.08	9,676.77	98.32	33,881.84	19.38	6,678.70	27.67	9,535.48
Jujuy	478.05	25.31	12,098.41	95.55	45,676.50	16.61	7,939.39	24.90	11,902.41
La Pampa	312.57	21.69	6,779.41	91.93	28,734.46	12.99	4,060.03	21.28	6,651.25
La Rioja	256.90	24.76	6,360.52	95.00	24,405.48	16.06	4,125.45	24.35	6,255.19
Mendoza	1,999.77	23.91	47,806.66	94.15	188,270.39	15.21	30,408.68	23.50	46,986.76
Misiones	484.70	29.23	14,167.50	99.47	48,212.89	20.53	9,950.60	28.82	13,968.77
Neuquen	507.16	21.52	10,912.25	91.76	46,535.50	12.82	6,499.92	21.11	10,704.32
Rio Negro	549.23	21.25	11,671.59	91.49	50,249.84	12.55	6,893.25	20.84	11,446.41
Salta	922.98	27.05	24,965.94	97.29	89,795.72	18.35	16,936.06	26.64	24,587.52
San Juan	653.81	23.81	15,565.51	94.05	61,489.32	15.11	9,877.34	23.40	15,297.45
San Luis	484.19	22.87	11,072.69	93.11	45,082.00	14.17	6,860.27	22.46	10,874.18
Santa Cruz	224.65	19.55	4,391.07	89.79	20,170.52	10.85	2,436.61	19.14	4,298.96
Santa Fe	3,545.94	26.98	95,652.73	97.22	344,719.28	18.28	64,803.09	26.57	94,198.90
Santiago del Estero	725.42	26.69	19,362.49	96.93	70,316.34	17.99	13,051.29	26.28	19,065.07
Tierra del Fuego	81.41	19.38	1,577.71	89.62	7,296.03	10.68	869.43	18.97	1,544.33
Tucuman	1,057.18	27.20	28,752.71	97.44	103,008.84	18.50	19,555.27	26.79	28,319.27
Argentina	**36,506.56**	**24.80**	**905,193.58**	**95.04**	**3,469,414.17**	**16.10**	**587,586.53**	**24.39**	**890,225.89**

Table 4: Total Potential Revenue: Volumes from EVAL 2010

Column(1) show volumes of waste from EVAL2010. Columns (2),(4),(6) and (8) are the same total external costs from Table 3. Column (3)=Column(1)* Column(2), Column (5)=Column(1)* Column(4), Column (7)= Column (1)* Column(6) and Column(9)= Column(1)* Column(8). Columns (3),(5),(7)and (9) represent the potential net revenue of applying an optimal tax.

Province	Quantity	No flaring					Flaring		
	(tons/day)	Low end		High End					
		Total external cost/ton	Potential net revenue ($/day)	Total external cost/ton	Potential net revenue ($/day)	Total external cost/ton	Potential net revenue ($/day)	Total external cost/ton	Potential net revenue ($/day)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Buenos Aires	22.773,74	25,64	583950,77	95,88	2183578,20	16,94	385819,24	25,23	574613,53
Catamarca	331,05	25,79	8537,53	96,03	31790,15	17,09	5657,44	25,38	8401,80
Chaco	949,73	28,51	27073,88	98,75	93783,13	19,81	18811,20	28,10	26684,49
Chubut	626,20	20,94	13109,99	91,18	57094,48	12,24	7662,03	20,53	12853,25
Cordoba	4.069,92	25,97	105690,51	96,21	391561,51	17,27	70282,22	25,56	104021,84
Corrientes	972,74	27,91	27147,13	98,15	95472,60	19,21	18684,26	27,50	26748,30
Entre Rios	1.211,27	26,29	31844,20	96,53	116924,09	17,59	21306,11	25,88	31347,57
Formosa	477,15	28,08	13398,60	98,32	46913,32	19,38	9247,43	27,67	13202,97
Jujuy	605,98	25,31	15336,01	95,55	57899,78	16,61	10064,01	24,90	15087,56
La Pampa	392,31	21,69	8508,85	91,93	36064,68	12,99	5095,75	21,28	8348,00
La Rioja	300,28	24,76	7434,37	95,00	28525,89	16,06	4821,96	24,35	7311,26
Mendoza	1.704,15	23,91	40739,59	94,15	160439,12	15,21	25913,48	23,50	40040,89
Misiones	1.079,56	29,23	31554,88	99,47	107383,26	20,53	22162,70	28,82	31112,26
Neuquen	678,06	21,52	14589,21	91,76	62215,95	12,82	8690,11	21,11	14311,21
Rio Negro	785,53	21,25	16693,09	91,49	71868,95	12,55	9858,95	20,84	16371,02
Salta	1.093,00	27,05	29564,93	97,29	106337,03	18,35	20055,86	26,64	29116,80
San Juan	667,43	23,81	15889,79	94,05	62770,35	15,11	10083,12	23,40	15616,15
San Luis	423,66	22,87	9688,61	93,11	39446,75	14,17	6002,73	22,46	9514,90
Santa Cruz	336,98	19,55	6586,60	89,79	30255,77	10,85	3654,91	19,14	6448,44
Santa Fe	3.929,28	26,98	105993,57	97,22	381986,23	18,28	71808,83	26,57	104382,56
Santiago del Estero	786,61	26,69	20995,47	96,93	76246,64	17,99	14152,01	26,28	20672,97
Tierra del Fuego	156,46	19,38	3032,15	89,62	14022,06	10,68	1670,93	18,97	2968,01
Tucuman	1.303,37	27,20	35448,55	97,44	126997,20	18,50	24109,24	26,79	34914,17
Argentina	**46.134,66**	**24,80**	**1.143.925,95**	**95,04**	**4.384.424,50**	**16,10**	**742.554,40**	**24,39**	**1.125.010,74**

Figure 1: Municipal Solid Waste generation 1996-2012



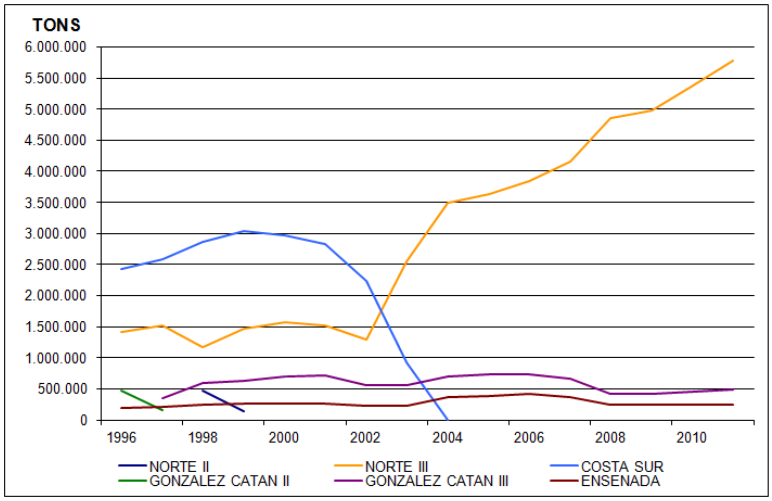
Based on CEAMSE and ECRSU data.

Table 5: Waste Generation 2010

Column (1) presents tons of Municipal Solid Waste collected from CEAMSE. Column (2) has Census data. Column(3)= Column (1)/ Column (2)/365 days

Jurisdiction	Volume (Tons) (1)	Population (2)	Per capita generation (kg/day) (3)
Buenos Aires City Total MSW	2,110,122.2	2,890,151	2.00
Buenos Aires City Total MSW + domiciliary, scavenging and others	1,419,584.4	2,890,151	1.35
Gran Buenos Aires (City+24 jurisdictions)	4,385,248.4	12,806,866	0.94
CONURBANO (33 jurisdictions)	3,311,388.2	11,442,928	0.79
AMBA	4,730,972.6	27,139,945	0.48

Figure 2: Municipal Solid Waste disposed by landfill 1996-2011



Based on CEAMSE data.

Table 6: Spillover Effect

(1) Data from EVAL2010. (2) Based on census data. (3) and (4) Based on the difference with Zero Waste Act goals. According to Buenos Aires City Government (GCBA) the goal was 1,048,359.2 tons, while according to CEAMSE the goal was 1,045,007 tons.

	Per capita	Volume	Difference with Zero Waste Act Goals	
	Generation (Kg/day) (1)	(Estimated Tons) (2)	GCBA estimation (3)	CEAMSE estimation (4)
Spillover	1.41	1,487,416.21	439,057.01	442,409.21
No Spillover	1.22	1,286,984.24	238,625.04	221,977.24