

Lessons for Compost Policy: What Can Recycling Policy Tell Us?

Michael Brady

School of Economic Sciences, Washington State University

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Abstract

This report pertains to the question of how to design a recycling program to achieve a certain goal (such as a certain level of organics diversion) most efficiently (lowest cost). Compost collection programs have spread to a number of municipalities in the U.S. for the first time in the last few years. Therefore, now is a good time to assess whether the design of these programs may have an effect on how well they meet goals. It is still too early to have enough information on these programs to assess them directly. The approach of this study is to provide a summary of the economics literature on recycling programs, which go back to the late 1990s. While caution is required in extrapolating lessons from recycling programs to compost programs, there are enough similarities that make it worthwhile. The consensus from this body of literature was that policy intervention at the middle of the waste stream, or the household curbside, is relatively inefficient, even if all social costs are properly priced in. The reasons for this include a lack of incentive to get final recyclable product to end users, and the fact that available empirical evidence from recycling programs suggests that households are fairly non-responsive to pricing (their response is “inelastic”). While it is a significant departure from current policy that would need further study, a tax-based approach (i.e., a landfill tax) might provide a statewide context that would encourage some municipalities to adopt composting (those in which the benefits outweigh the costs), without requiring action for those municipalities where costs would outweigh the benefits. That said, it may still be worth reconsidering the move to single stream recycling in terms of whether the public can be relied upon to separate waste in some instances. For example, it could be that this is a good option in less dense or more dense cities, which gets to another conclusion from the economics literature that there is no one-size-fits-all approach. In addition, recent recycling experience suggests that a focus on compost value – and in particular limiting contamination, may be critical. In this regard, standards are one area receiving increased interest lately, including bans on problematic components of the waste stream such as plastic bags or straws. In addition to reviewing lessons from the recycling literature, the analysis also considered the possibility of two demand side policy interventions specifically focused on increasing agricultural use of compost. Available evidence suggests that refocusing subsidy from collectors to buyers (farms) is likely to have little effect. Instead, reducing the high up-front costs that farmers would need to invest in specialized equipment in order to experiment with compost via equipment sharing programs or other means would be more likely to influence compost demand from farms.

Introduction

“Solid waste policy should provide correct incentives for both ‘upstream’ and ‘downstream’ decisions. Upstream, it should encourage product design to reflect environmental concerns, and downstream it should encourage recycling, diverting solid waste from landfills.” Calcott and Walls (2005)

Municipal organics collection and composting programs across the U.S., including those in western Washington, have expanded significantly in recent years. This expansion has been driven by the willingness of many citizens to pay extra to reduce their environmental impact by having their compostable waste collected separately – and by policies that require recycling or recovery of organic wastes. In contrast to a typical market, the amount of compost produced is determined by population, household food purchases, landscaping, and waste collection programs, which are *supply side* factors. It does not depend on *demand side* factors, such as how much compost farmers or other end users are willing to purchase at different price levels.

The challenge for policy makers is that there are so many ways to design a compost program. In addition, the experience with recycling more broadly is that design matters. Different approaches are likely to affect outcomes including the amount of material diverted from landfills, and the benefits and costs to various parties in the system. Consider the waste generation pathway as shown below in Figure 1. There is an opportunity to affect the waste stream at every arrow. Standards such as bans on certain materials, or requirements that packaging be compostable, can affect the quantity represented by the purple arrow. The approach to curbside waste, recycling, and compost collection programs will affect the quantities flowing through the green and red arrow. The tipping fee approach to incentivize compost suppliers to collect from the curbside is an example of a green arrow approach. Another option would be to subsidize the purchase price of compost by a farmer (blue arrow). Other policies that are important to consider may not even act directly on the waste stream. A carbon tax to curb greenhouse gas emissions would raise the price of fossil fuel based fertilizer (orange arrow), which would make compost more cost competitive by raising the price of a substitute.

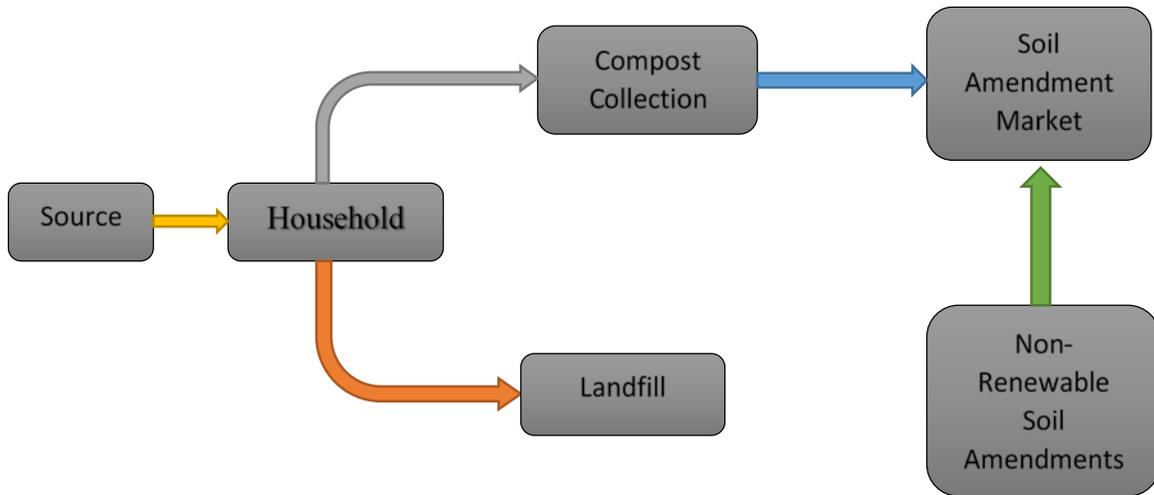


Figure 1. The household waste and compost generation pathway.

Background Relating to the Approach Used

Two possible different questions that can be asked include the “why” and the “how” of implementing organics diversion and recycling programs. This report pertains to the “how” question, which asks the question of how to design a recycling program to achieve a certain goal (such as a certain level of organics diversion) most efficiently (lowest cost).

In contrast, an economic approach to the “why” question would be to compare the benefits of the program relative to the costs. Within this approach, an analysis should attempt to include all costs including externalities, not just those that are currently reflected in prices. For example, if compost used by farmers leads to a reduction in inorganic fertilizer use, and therefore a reduction in greenhouse gases, this should be quantified as a benefit even if there is not currently an active carbon market. Benefits and costs should also reflect impacts that occur in the future. Including all costs and benefits is, not surprisingly, difficult to do in practice, especially when considering the future.

The challenge of considering future repercussions of actions taken now underpins the concept of sustainable development. The idea was first formalized by the Brundtland Commission in the book *Our Common Future* (1987), and it was very successful in galvanizing the scientific community towards the goal of developing integrated models of biophysical and human systems that would inform society as to whether current paths of resource use were sustainable. One key point made through this work was that existing patterns of industrial production, consumption, and technology are often developed without any regard for the finiteness of resources (McDonough and Braungart, 2000; Garcia-Perez, 2013), and that it is imperative to focus on the design of products from the outset (McDonough and Braungart, 2000). Another was that there was enough low hanging fruit (actions that could be relatively easily taken that would

substantially improve sustainability) that sustainability could be achieved without a radical reduction, or in some cases an improvement, in current living standards.

An alternative framework that leads to the same general policy prescription of acting now to more responsibly use natural resources was provided by economist Martin Weitzman (1974) fifteen years before the Brundtland Commission. Weitzman's probabilistic/risk management approach is more straightforward than sustainable development because it deals with uncertainty about the future head-on. Weitzman argued that catastrophic events, like a collapse in food production due to climate change, deserve action now even if the probability of catastrophe is low because societies voice through political action an aversion to risk.

Sustainability has served as a fundamental rationale for the adoption of recycling and organics diversion. However, it is also fair to say that the concept of sustainability has not proven to be *on its own*, enough to design policy, though it certainly informs it. There are a few reasons for this. First, sustainability must contend with the inherent uncertainty relating to impacts that occur in the future. Second, sustainability is usually not a binary choice (with one clearly "sustainable" choice and one entirely "unsustainable" choice) (Neumeyer, 2003). Instead the question is more likely one of degree: different policies may lead to slightly cleaner air and water, but are unlikely on their own to be the difference between humanity thriving and mass extinction.

Because the question is one of degree, there is a necessary and important *political* process by which societies make these types of decisions. When faced with such uncertainty over the future, it is perfectly reasonable for individuals to express through a political process a desire to err on the side of caution in terms of preserving the environment and natural resources, but this political process is distinct from economic analysis. An economist can give a menu of efficient policies, but only the political process can choose which option best meets priorities. This review was focused on just that: given organics diversion goals, what policies can be used to meet these goals at relatively low cost with relatively few unintended consequences.

The objective of this report is to provide perspective on whether interacting with the waste and compost stream at various points along the system may be more effective than others. The ideal way to study this would be to create a large data set on compost programs in many locations with information on outcomes (e.g., cost, quantity to landfills, quantity composted) and perform a statistical analysis to see which program approaches were most effective. However, this is not feasible with compost programs because they have only been implemented recently in the U.S. A next best approach is to review studies that have potential to inform compost policy even though they are not explicitly on compost. One relevant area of study reviewed in this report is the adoption of alternative practices and technologies by farmers. There are important lessons from this literature on how farmers weigh potential gains relative to potential losses when there is uncertainty. Findings point towards a specific policy approach. The second major area of study reviewed is the sizeable literature analyzing recycling programs. Compost is a type of recycling program that focuses on organic materials as opposed to glass, metal, or some other material. While the nature of the material being reused is an important consideration in how to design a program, there are important similarities. Importantly, general recycling programs have existed

for much longer, so there is a chance to learn from what works and what does not. From the mid-1980s to mid-2000s, the number of households in the U.S. with access to organized recycling services as part of their waste collection services went from almost none to 48% of the population, which was the outcome of more than 8,000 municipalities developing recycling programs (Kinnaman, 2006). The result has been consequential. Kaufman et al. (2004) estimates that diversion rates of waste to recycling exceeded 30 percent by the year 2000.

In order to limit the scope of the analysis, this report focuses on the economics literature on waste management and recycling. The most important part of any economic analysis of a specific policy, or a comparison of alternative policies, is to be explicit about the assumed objective. There are two general approaches. One is to identify the policy that creates the highest net benefit to society. It is beyond the scope of this report to summarize what is meant by “net benefit,” but it is important to recognize that one can consider both total benefits and the distribution of benefits (i.e., equity). The second approach is to identify the best policy for achieving a specific goal. This approach has the benefit of explicitly separating out the political process from the scientific approach of economics. For example, it is up to the political process to determine the Federal government should provide guaranteed health insurance for every citizen. If this choice is made in the affirmative, then it is the job of economists to find the most cost-effective way to achieve this goal.

Carrying this second approach over to municipal waste management, recycling, and compost programs, an economist can evaluate whether a specific program is efficient in achieving outcomes. A commonly used example of this type of analysis is a benefit-cost analysis (BCA), which provides a comparison of whether benefits exceed costs. Benefit-cost analyses are valuable when evaluating a specific policy on its own. When a basket of alternative policies are being considered, it is more common to do a cost-effectiveness analysis to identify the lowest cost option – or to consider which policy generates the greatest benefits if costs are about the same. This report consists of two different approaches. In one scenario, it is assumed that additional funding is made available to subsidize some aspect of agricultural purchases of compost. It is not the position of this report that there *should* be a subsidy. The second approach that incorporates the recycling literature assumes no meaningful change in funding.

Considerations in Extending Recycling Findings to Composting Policies

It is important to recognize that compostable materials are just one type of recyclable materials. Therefore, it is conceivable that all of the policy levers considered for recycling could apply to composting. That said, just as there are economic and physical differences between aluminum and glass, organic wastes have important differences from other recyclable materials. For example, it seems unrealistic that a deposit/refund approach used for glass bottles could be applied to, say, bananas because the banana peel degrades much more in the time it is handled by the consumer. Therefore, any recycling policy that relies on the material maintaining its physical structure will be less relevant to compost. The other thing to keep in mind is that the demand for compost is less well developed than some recycling materials. That said, it is also the case that there are substantial differences between industrial processes and markets for paper versus glass versus aluminum, and yet some general lessons can be drawn across recycling types.

Economic Perspective on Municipal Solid Waste Management

Solid waste collection only became a widespread part of municipal public services in the 19th and early 20th centuries. This innovation occurred because there was a significant public health benefit from making it as easy as possible for people to get garbage out of their residences as quickly as possible while minimizing the incentive to illegally dispose of waste (DeLong, 1993). In this way, it is one of the great public infrastructure developments, like sewage systems, that developed contemporaneously.

From the perspective of recycling, an interesting question is to ask why did most municipal solid waste collection programs initially take a “single stream” form, where all waste, no matter the type, is collected and disposed of together? DeLong argues that this is due to the fact that in the early 20th century, collection was eight times as expensive as disposal, which made separating waste streams financially infeasible. All garbage was combined even if some of it would have value as an input for a production process such as composting or non-organics recycling. The collection and processing costs were too high to be competitive when there were abundant stocks of raw resources that could be used to produce inputs that were substitutes for reusable waste (e.g., fossil fuels for inorganic fertilizer production). A second common feature of these municipal solid waste collection programs was zero marginal cost pricing, which means that households paid a fixed fee rather than paying in accordance with the amount of waste disposed. Volumetric pricing is administratively burdensome, so it is not surprising that most cities collected payment for waste collection services through the general tax or utility system. The downside to this approach is zero marginal cost pricing leads to overproduction of waste.

From an economic perspective, overproduction means that the cost exceeds the benefit at quantities being produced. This does not mean that no waste *should* be produced. Consider waste from food in a situation where there is a lot of available space and very little waste is yet being produced. The benefit of generating the waste is that someone was able to eat, so the benefits are very high. Also, the cost of disposing the waste is relatively low. In the case of food, someone did not starve and there is ample space to dispose of the waste without causing much damage. However, as populations grow and cities swell, the easy low cost landfill options get used up. In the 1980s, tipping fees charged by garbage collectors tripled in less than ten years, which was attributed to tighter environmental regulations and growing land scarcity (Steutville and Goldstein, 1993). Moving onto less ideal sites increased nuisances of all sorts and presented a greater risk of contamination which was not reflected in the price households pay (Callan and Thomas, 1997). At the same time, a drawdown in natural resource stocks created an impetus to reuse materials.

The policy basket

It has long been understood that traditional flat fee waste disposal pricing for a single combined stream causes a problem; this is the easy part. The more difficult task is identifying better approaches to reducing the waste stream given all the alternatives. The major categories of approaches that have been implemented in the real world to promote resource recovery via recycling are:

- Fees: also called pricing or unit based pricing;
- Deposit/refund;
- Advance disposal fees (fee added to consumer product to account for disposal costs);
- Taxes;
- Tax-subsidy combination;
- Standards;
- Location (e.g., curbside versus drop-off); and
- Regulations with fines.

In practice, there are numerous variations within each broad category. These differences are discussed in the next section. The point of the waste stream where the policy acts is often critical to the effectiveness of the policy. At each arrow in Figure 1, there is the opportunity to affect the price paid or received, or the quantity of materials. For example, one way to affect the transfer between households and the reuse/recycling/compost is a common volumetric fee is bin size block pricing where households pay more for larger disposal bins. Here are some example policy questions that take the point of interaction into consideration:

- Is it better for government to put a quantity limit on product production (source) or the middle (household → landfill) of the waste stream?
- Should government incentivize compost use by subsidizing its production (e.g., tipping fee) or its purchase by an end user?
- When is it better to have strict standards on packaging rather than trying to “nudge” people to change their behavior at the household level during disposal?

The case for subsidizing compost spreading equipment

Before proceeding to consider studies that look at recycling program design broadly, there is an action more focused on compost that should be considered. Currently, there is no direct subsidy to the purchaser of compost. There is an implicit subsidy in that composters receive a payment

for collecting compost, which should lower its cost. If more public funding were available to subsidize compost purchases, the recommendation of this report is that it go towards compost spreading equipment. The challenge for some farms is that compost requires a specific type of machinery that they do not already own. Even if compost was heavily subsidized, it would still be necessary for a farmer to invest in new equipment. There are many research articles showing that this creates a huge barrier.

The basic idea behind these studies is that most farmers have been shown to be “loss averse”. Most everyone is familiar with the idea of being risk averse. Loss aversion is similar, but is different in important ways. Someone who is risk averse is willing to give up something to avoid a big loss. Insurance is the classic example. A farmer pays for crop insurance to avoid being completely wiped out by a drought or pest infestation. The insurance premiums lower their expected profit margin, but they consider it a tradeoff worth making. Someone that is not risk averse is not willing to make this tradeoff.

Loss aversion has to do with weighing a decision that could be either good or bad. For example, using a new wheat variety could increase yields, but there is a chance they are worse. A study of dairy farmers showed that the upside would have to be double the downside if both are equally likely (Bocqueho, et al., 2013). Another study of wheat farmers in China showed that a fear of losses considerably slowed the adoption of Bt cotton (Liu, 2013). Menapace et al. (2013) conducted experiments with farmers in the U.S. and found that uncertainty over probability that some action pays off was weighed more heavily than estimates of the gains.

What these studies show collectively is that farmers are very hesitant to expose themselves to losses if the gains are uncertain. There are many aspects of compost that fit this situation. First, there is a risk of introducing contaminants with the compost. Once imported onto the farm, contaminants in compost may be difficult or impossible to remove. One approach to the problem of contamination is discussed further in the section on Compost Program Design. Secondly, as discussed in a companion report (Hills et al, 2019), there is still significant uncertainty over how much compost will increase yields in different situations. Farmers may be okay taking this gamble if compost were cheap enough. However, even if a subsidy were to make compost really cheap, many would still have to go out and make a significant investment in new machinery. This introduces the potential for large losses if they don't see a benefit. A policy that would make a loss-averse farmer more willing to take a gamble is to make it so they do not have to make a capital investment in machinery. If spreading equipment were made available, even loss averse farmers might not mind spending some money on compost to give it a try. If it does not work, they are only out the money they spent on that one application of compost. What a farmer wants to avoid is being stuck with a loan on a piece of machinery that turns out to not be useful.

Compost Program Design

We now turn to consider how compost program designs would change based on findings from the recycling literature. The “status quo” that is being assumed through this discussion is a curbside organics collection program with a tipping fee paid to composters. This is not the only way compost programs are run, but it is the primary method.

First, would changing garbage collection programs fundamentally help or hurt compost collection goals? This question is important to consider because it could be that any changes to the compost program are swamped by the existing garbage collection program. One relevant result from the literature is that a fee structure for garbage that is a block pricing approach where households choose from a few different sizes is not that effective at reducing or diverting waste. Households put more effort into reducing or diverting waste if there is a fee that is based on the weight of what they throw out. This does require scales on garbage trucks that can weigh each bin as it is disposed of, which is costly. However, switching to this type of system would seem to increase effort by households in diverting compostable waste towards the compost bins and away from trash bins.

Second, could it make sense to follow the policy recommendation to replace the public subsidy put towards a tipping fee and replace it with a landfill tax and/or an agricultural compost use subsidy? To be clear, this is a radical shift in approach, which would require substantial additional analysis. However, the fact that it represents a large-scale change helps elucidate possible limitations from the current system. It is useful to think about the policy change as moving the public intervention in the compost market from the middle of the waste supply chain to the end, as shown in Figure 1. Looking first at the farm subsidy question, it can be shown with a fairly simple economic model that subsidizing a supplier, which currently takes the form of a tipping fee, versus subsidizing a buyer (e.g., farmer buying compost as a soil amendment) will result in the same outcome under some conditions. In other words, there is no reason to think the market will grow if funds currently going to composters for collecting compostable material were instead given to buyers of compost at the point of purchase.

Third, another alternative is to move the focus of policy from the middle to the very beginning through a focus on standards. This approach has the potential to improve the problem caused by contamination. There is increasing political momentum to outright ban waste that is especially problematic once it enters the waste stream. Plastic bags are the most well-known, but there is also movement on plastic straws. Plastic utensils are another potential target. It is possible that the most impactful change for developing compost demand is the elimination of a few waste types that cause contamination if they enter the compost stream.

As mentioned earlier, it is critical to expand the number of empirical studies exploiting differences in composting programs to understand fundamental relationships. There are a couple papers of this nature to date, although they are mostly from the Netherlands.

Lessons from the Rise (and Decline) of Recycling Programs

Our objective in this section is to review economic studies on recycling programs to consider the lessons for compost program design. We also look at whether there are any lessons to be learned from the decline in recycling programs in the past year. A concise summary of relevant studies is provided in the Appendix. What separates economic studies of recycling policies from other perspectives is a focus on “efficiency,” which typically comes down to minimizing the cost of achieving some objective. As discussed earlier in this report, this follows from the premise that waste collection programs in the absence of a recycling program charge too little, or even nothing, for waste disposal. The result is an overproduction of waste. A recycling program helps

ameliorate this outcome to some degree. The economics literature assesses whether some recycling programs achieve similar outcomes at lower cost than others. However, economic efficiency considers the possibility that it may not be efficient to divert every piece of material away from a landfill and towards a recycling facility that can be recycled. In other words, there is such a thing as “over-recycling” from this perspective. Putting material in a landfill has a cost including direct costs and environmental costs. However, it is possible that, in some cases, recycling a material requires so much human effort, capital costs, and energy that it is better to put it in a landfill.

Recycling programs spread across much of the U.S., Europe, and parts of Asia in the 1990s. Working from the diversity of approaches that were used at that time, economists and public policy scholars analyzed these programs to draw out lessons for the most efficient design of waste programs that incorporate recycling. Most of the published studies were conducted between 1996 and 2006. From about 2006 until recently recycling programs have been relatively mature with less policy experimentation, and the academic literature has been less active as a result. However, there is likely to be a renewed interest in studies reassessing recycling programs in the next few years in response to the unwillingness of China to accept recycled materials in 2018. This recent shift, driven in a large part by concerns relating to the poor quality and contamination of the recyclable materials, has sent shockwaves through recycling programs causing many municipalities to substantially alter the types of materials that are collected.

Theoretical studies

The economics literature on waste management began with purely theoretical treatments making the point that too much waste was produced by charging households a fixed rate for collection (Plourde, 1972; Smith, 1972; Wong, 1972; Zeckhauser, Spence, and Keeler, 1972). The timing of these studies in the 1970s likely contributed to conversations and political activity that led to the passage of the Resource Conservation Recovery Act (RCRA) in 1976 that put much tighter restrictions on siting of new landfills. While these studies are now more than 40 years old, they are useful and relevant today because their objective was to develop economic frameworks for assessing recycling programs in a very general way. They continue to be used in recent empirical studies to develop hypotheses that can be tested empirically with recent data.

A steady stream of purely theoretical papers have compared a larger basket of policies and examined interactions along the waste supply chain. These studies often provide the motivation for empirical studies in terms of developing testable hypotheses. A study that has a natural extension to composting is Calcott and Walls (2000) who looked at “Design for Environment” standards in combination with taxes on packaging producers that corresponded to percent recyclable. They determined that there are significant challenges in effectively implementing this type of system. A later study by the same authors showed situations in which deposit-refund and curbside recycling collection programs can be successfully combined (Calcott and Walls, 2005). Fullerton and Wu (1998) also consider materials packaging incentives in the presence of a number of other policies. They identify conditions where volume-based garbage fees to households produce the same amount of waste as a tax/subsidy on packaging producers that is determined by the percent of recyclable packaging.

There are also a number of theoretical analyses comparing deposit/refund policies. Palmer et al. (1997) compares deposit/refund, advance disposal fee, and a recycling subsidy. They find that compared to the other two approaches, a deposit/refund policy is a much cheaper (half the cost) way to achieve a particular level of waste reduction because it creates incentives to reduce waste to landfills at both the source and the separation of non-recyclable and recyclable household waste. In comparison, advance disposal fees and subsidies only either reduce source material or recycling rate, but not both. An advance disposal fee is a charge put on consumer goods when they are purchased. It is like having a deposit/refund system but without the refund. A more recent theoretical article by Kinnaman (2010) contends that it is important to consider sorting technologies. He argues that given current technologies available, it is cheaper to sort recyclables centrally rather than at the household.

Empirical studies

Economists value theoretical studies because they clarify ideas and are central to formulating hypotheses. However, more value is always placed on empirical studies that can actually test whether certain relationships exist in the real world. This distinction is particularly important in the recycling context because a large number of empirical results find that well-designed garbage fees are not the best policy approach. This also is relevant later in this report when findings from recycling studies are used to make conjectures about compost policies. The gold standard for informing compost policy would be to have data on compost program design and various outcomes. Hopefully, this type of data set will be available in the future.

Wertz (1976) carried out the first empirical study that sought to test the prediction coming from theoretical papers that charging volumetric fees would reduce waste. He found that higher fees did indeed reduce waste, and estimated an elasticity of -0.15, so a 10% increase in the price per unit for waste reduced output by 1.5%. This is in the range generally considered to be “inelastic,” meaning that it takes large increases in fees to cause sizeable reductions in waste produced. It took another 15 years for another wave of studies to be done. Authors of these studies arrived at similar estimates with elasticity values between -0.12 and -0.26 (Skumatz and Breckenridge, 1990; Morris and Byrd, 1990; Hong et al., 1993). Jenkins (1993) estimated the price elasticity for waste production to be -0.12. This translates to about a 10% reduction in quantity of waste for a \$1 (\$0.70 in 1993 dollars) increase for a 30 gallon container. So, there was early support for predictions that households would be responsive to fees corresponding to the amount of garbage they disposed of, but values were well within the “inelastic” range. Because recycling programs were not widespread until a few years later, these studies did not consider what happens when fees are combined with curbside recycling. There was some variation in the fee structure including a fee based on the number of containers and one based on the size of the container. Kinnaman and Fullerton (1996) found that the introduction of unit pricing for garbage reduced the volume but not the weight of waste produced by households.

Another group of studies also showed that waste generation increases with income, but is also solidly in the inelastic range (Richardson and Havlicek, 1974, 1978; Wertz, 1975). The average of the studies cited was about 0.25, so households with a 10% higher income than the average produce 2.5% more waste. Johnstone and Labonne (2004) also look at income elasticity in waste generation, but use aggregate data over time for OECD (Organization for Economic Co-

operation and Development) countries. They estimate an income elasticity similar to previous studies.

Kinnaman and Fullerton (2000) looked at the effect of introducing a garbage fee along with a curbside recycling program on diversion rates from landfills. They found that charging households directly for waste disposal on a per unit basis (\$1 per bag from \$0) reduced waste going to landfills by 412 pounds per person per year. However, they also found that charging more for garbage only increased recycling amounts modestly (30 pounds per person). Jenkins et al. (1993) arrived at a similar finding. While they did show that curbside programs increased recycling rates relative to drop-off, they cautioned that the difference was probably not large enough to make up for the higher cost of curbside recycling. Ferrera and Missios (2005) analyzed data on post-consumer waste diversion rates in Ontario, Canada under a range of recycling programs on different materials. They showed that garbage fees are not likely to increase recycling if garbage fees only kick-in above some threshold.

Three highly influential papers were published within a couple years of each other around 1999 that provided a more nuanced view of the interaction between various waste policies on the total amount of waste produced and waste diverted. Chronologically, the first of these studies was Podolsky and Spiegel (1998) who disentangled the effect of garbage fees and recycling on total waste production. They define the indirect and direct effects of a garbage fee to be the change in amount of recycling and garbage, respectively. They estimate a negative price elasticity of -0.39 for garbage fees, so higher prices reduce quantities. But they do not consider that this estimate may change with and without recycling.

Hong (1999) found that higher recycling rates caused by higher garbage fees increase waste generation compared to outcomes without a recycling option. The implication of this finding is that higher garbage fees increase recycling, but do not decrease total waste generation (garbage and recycling). In fact, Hong estimates a positive price elasticity (0.121) for garbage fees when there is recycling, so higher fees may actually *increase* waste generation.

The third study in this cohort is Kinnaman and Fullerton (2000). This study also looked at the effect of garbage fees and recycling program design on waste output and recycling rates. Their innovation from earlier studies was to consider the potential that characteristics of the municipality, which also influence waste output and recycling rates, determine the choice of waste and recycling program design. They argued that previous empirical studies are overestimating the extent to which garbage fees and recycling programs *cause* households to produce less waste and recycle more. The logic is as follows. Communities that have low recycling rates without a curbside recycling program are more likely to adopt one because there is a greater potential for change. Therefore, one is likely to overestimate the causal effect of adopting a curbside program on recycling rates for any given community. They also gathered data on a much larger set of communities than earlier studies, which made it possible to estimate a “cross-price effect” of a garbage fee on recycling quantity, which looks at whether a higher price for waste disposal increases recycling rates.

Based on a broad review of the literature to that point, Kinnaman (2006) arrives at policy recommendations that would represent a substantial change to the status quo. First, eliminate

statewide requirements that there be a curbside collection of recyclable materials. Kinnaman argues it is more efficient to have sorting of waste and recyclable materials conducted centrally at a waste facility. He then argues for eliminating quantity (volumetric or weight-based) garbage fees on the basis that empirical studies show that they have little effect on waste production in the long-run. Note that this is in stark contrast to early policy recommendations in the economics literature that were not yet informed by empirical analysis. The critical policy addition that Kinnaman argues for is a landfill tax that, in effect, replaces the household focused policies of curbside recycling and garbage fees. These would be major changes to waste policies even today, so how did Kinnaman arrive at this recommendation? His conclusion is based on results from the studies discussed that would predict that a landfill tax that captures the full social cost of waste will cause *some* municipalities to voluntarily institute curbside recycling programs, but not others. The key insight is that municipalities that have high disposal costs will pursue curbside recycling. This avoids municipalities being obligated to have a costly curbside program even when the social costs of waste are lower than the cost of recycling.

Summary of Recommendations

Taken as a body, the literature on recycling suggests several lessons relevant to composting programs:

- Empirical analysis is critical for projecting the effect of changes in policies. We are on the cusp of having enough experience with municipal composting programs that empirical studies could be performed to evaluate the relationship between approach and outcomes.
- Volume or quantity fees for waste disposal are the simplest to implement, but households are not that *responsive* to fees. This is particularly the case for the cross-price effect of garbage fees on recycling rates (i.e., increasing garbage fees in the hopes of enhancing recycling rates). What this means for compost is that increasing the price that households pay for disposing of waste to landfills may not have much of an effect on the amount of compostable waste diverted from the waste stream.
- Waste production increases with income, but at a fairly slow rate (i.e., income elasticity of demand for waste is positive but is highly inelastic). The implication for compost is that there is little reason for pessimism that higher income households will generate a lot more compostable waste than lower income households.
- While a significant departure from current policy that would need further study, a tax-based approach (i.e., a landfill tax) might provide a statewide context that would encourage some municipalities to adopt composting (those in which the benefits outweigh the costs), without requiring action for those municipalities where costs would outweigh the benefits. This finding is important to contrast with the second bullet point. While households are not that responsive to prices charged for putting waste in landfills, waste management entities (public or

private), are very responsive. This makes sense given that households have lots of other day-to-day concerns, while waste management entities have most of their attention focused on these issues. Therefore, a landfill tax is more likely to increase the amount of compostable waste diverted from landfills than a higher waste fee charged to households.

- There are some interesting results showing that deposit-refund policies are effective, but they probably have less relevance for compostable materials.
- Though the literature on this topic did not provide specific evidence related to the effect of standards on contamination levels, it would stand to reason that a focus on standards may be helpful to reducing contamination, and thus increase the *value* of the compost product. There is increasing political momentum to outright ban waste that is especially problematic once it enters the waste stream. Plastic bags are the most well-known, but there is also movement on plastic straws. Plastic utensils are another potential target. It is possible that the most impactful change for developing compost demand is the elimination of a few waste types that cause contamination if they enter the compost stream.
- If additional funding were made available, subsidizing the purchase and deployment of compost spreading equipment could be the best path for increasing compost use on farms. This follows from the logic that farmers are very hesitant to make large capital investments in machinery they are not sure will pay off.

Conclusions

Compost programs are at a similar stage as recycling programs were in the mid-1990's. They have recently been implemented in many municipalities, but it is still early in terms of assessing the effectiveness of different approaches. Given that compost is one type of recyclable material, it makes sense to identify key findings from the economics literature on recycling to potentially learn valuable lessons about how best to design a compost program to meet a specific goal. Economics provides a valuable framework because it is standard to explicitly state the objective. The ideal policy approach may differ depending on whether the goal is to minimize the waste stream to landfills or to minimize costs. It is important to consider that when households do not pay enough for having their waste disposed of in a landfill, there will simply be too much garbage. However, it is also the case that it takes labor, capital, and energy to divert recyclables from the waste stream and turn them back into materials that can be used in consumer products. It is possible that the costs of recycling some materials are higher than if they were disposed of in a landfill. Solid waste policy makers are left with a difficult two-fold problem. How much waste that can be recycled should be recycled? What is the policy approach that achieves that level of recycling at the lowest cost? The point of this report is that the same two-fold question is faced by those designing compost programs.

As discussed in this report, the economics literature on recycling arrived at a general consensus that policy intervention at the middle of the waste stream, or the household curbside, is an inefficient approach even if all social costs are properly priced in. The suggestion to move policy

intervention to the ends of the stream by focusing on standards and landfill taxes would be a radical change to the dominant curbside tipping fee approach used now. It is worth noting that the argument to focus on product design standards aligns with the economics literature on recycling and those coming from a design background like McDonough and Braungart even though they came at the problem from very different perspectives. The two perspectives do differ in their focus on how to achieve better design. Economists pay greater attention to implementing policies that provide financial carrots and sticks to ensure that changes happen. The design and sustainability literature rely more on persuasion to try and change norms of product designers and other decision makers in the design arena. Importantly, these are not mutually exclusive actions, and both strategies are likely needed. A useful parallel to this “both/and” approach comes from residential lawn watering where charging higher prices for water and giving people information about how much water their neighbors use both lower water use.

One caveat to these conclusions from the recycling literature is that it is possible that compost is substantially different enough from other recycling to nullify some aspects of these policy recommendations. There are significant differences in organic waste that can be converted into compost and other recyclable materials. Furthermore, there are other organic waste options being implemented in the PNW region. These include anaerobic digestion at very small and large scales, and co-digestion with agricultural wastes to produce methane, and organic fertilizers. Organic waste does not have the potential to damage machinery the way that glass can. Also, there is less of a need to separate one type of compostable material from another, although it is critical to separate out non-compostable material that results in contamination. One clear recommendation that falls out from the recycling literature is to avoid blanket requirements that all municipalities within a state have curbside compost collection. Another result that simplifies policy considerations is that changes to pricing to households on garbage (not compost) probably will not affect how much waste gets recycled, but landfill pricing could create meaningful incentives for waste management companies to separate out compostable materials.

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Appendix

Summary of prominent economic studies analyzing recycling and compost policies.

Study	Policies Evaluated	Region	Empirical	Main Conclusion
Recycling				
Bel and Gradus (2016)	Fees	Global cross-section	Y	A meta-analysis of 25 studies. Price elasticity of demand for garbage collection is inelastic but more elastic if pricing is weight-based and there is pricing for compostable waste.
Calcott and Walls (2000)	Taxes; standards		N	Taxes on products based on percent recyclability, following a "Design for environment" approach, are not feasible to implement.
Calcott and Walls (2005)	Location of collection; deposit/refund; fees; standards		N	It may make sense to have deposit-refund policies even when there is free curbside recyclable collection.
Callan and Thomas (1997)	Fees; location	Massachusetts	Y	Recycling rates 6.6% higher in communities that charge a fee relative to amount of waste disposed compared to those that do not. This value increases by another 5.5% if the recycling is curbside rather than dropoff.
Callan and Thomas (2006)	Fees; location	Massachusetts	Y	Provide support for Hong (1999) showing both direct and indirect effects from garbage fees. Find that a 1% increase in unit pricing diverts 5.2 pounds/person/year from the waste stream to recycling.
Ferrara and Missios (2005)	Fees	Ontario, CA	Y	Garbage unit fees significantly increase recycling intensity, but NOT if some free garbage units (up to a limit) are allowed. Garbage bag limits w/o a unit fee did not increase recycling, and can even reduce it. A mandatory recycling program was equivalent to garbage fees in achieving recycling rates.
Fullerton and Kinnaman (1996)	Fees	Charlottesville, VA	Y	Going from no fee to \$0.80/32 gallon bag had only a very small reduction in waste production as measured by weight. Corresponds to an elasticity of -0.076.

Fullerton and Wu (1998)	Large basket of policies		N	Show theoretically that the same reduction in waste through changes in packaging can be achieved by a fee on garbage disposal to households and a tax/subsidy on producers that corresponds to their packaging design and use of recyclable materials.
Gitlitz (2002)	Material		Y	Aluminum can recycling decreased from 65% to 50% from 1992 to 2001.
Hong (1999)	Fees	Korea	Y	Important feedbacks between recycling and waste generation with volumetric fees. Higher recycling rates caused by higher garbage fees increase waste generation compared to outcome with no recycling option. The implication is that higher garbage fees increase recycling, but do not decrease waste generation. Hong estimates a positive price elasticity (0.121) for garbage fees when there is recycling, so higher fees increase waste generation.
Hong and Adams (1999)			Y	Interaction between container size pricing and recycling. Found that higher prices for larger bins has a large effect on increasing recyclables than decreasing non-recyclables disposed.
Hong et al. (1993)	Garbage fees; recycling		Y	Garbage fees increase recycling rates.
Hottle et al. (2015)	Recycling; composting		Y	Focused on large venues rather than residential, and considered CO ₂ emissions. Recycling program with costly bin monitoring significantly reduced CO ₂ emissions. Composting was very effective in diverting waste from landfills, but did not reduce CO ₂ emissions.
Jenkins (1993)			Y	Estimates a negative price elasticity of garbage fees on waste quantities. But these results should be viewed in the same light as Podolsky and Spiegel (1998) given findings from Hong (1999).
Jenkins et al. (2003)	Fees for waste (unit rates or block pricing)		Y	Unit prices for garbage had no impact on recycling.

Kinnaman (2006)				Review article. Concludes based on many studies that price elasticity of demand for garbage collection is inelastic. Recommends replacing curbside recycling and mandatory recycling programs with landfill taxes.
Kinnaman and Fullerton (2000)		Sample of 908 U.S. communities.	Y	Empirical evidence shows that the choice of recycling policies depends on city characteristics. Find disposal demand is price inelastic (-0.034 to -0.778). Similar to Podolsky and Spiegel (1998), their estimate of the effect of garbage price on recycling quantity is not statistically significant.
Kinnaman (2010)	Fees; taxes		N	Argues that the most effective place on the waste stream to charge a per unit fee is at the landfill rather than the household "curb." This finding is directly related to the presence of technologies that can sort materials at a centralized facility, which leads to too much sorting effort by households rather than at recycling facilities. More importantly, curbside fees do not incentivize recyclers to internalize the cost of waste disposal.
Linderhof et al. (2001)	Garbage fees	Netherlands	Y	Garbage fees reduce total waste generation.
Miranda and Aldy (1998)		9 communities in U.S.	Y	Households respond to unit pricing by decreasing waste and increasing recycling if it is an option initially. Eventually, households alter purchasing decisions.
Nestor and Podolsky (1998)	Fees	Marietta, GA	Y	Little to no reduction in waste generation with fees.
Palmer et al. (1997)	Deposit/refund; advanced disposal fees; subsidies		N	Deposit/refund is the least cost method for achieving certain recycling rates. 7.5% reduction in wastes was efficient in 1990.
Podolsky and Spiegel (1998)	Fees	New Jersey	Y	Estimates a negative price elasticity of -0.39 for garbage fees, so higher prices reduce quantities. But they do not consider that this estimate may change with and without recycling as Hong (1999) did. Clarify difference between direct (garbage quantity) and indirect (recycling quantity) price effect. They estimate both effects to be negative, but on direct effect is statistically significant.

Rechovsky and Stone (1994)			Y	Curbside recycling increases recycling rates significantly.
Richardson and Havlicek (1974)		Indianapolis, IN	Y	Income and household size are the largest determinants of the amount of waste a household produces.
Richardson and Havlicek (1978)			Y	Estimate the relationship between household characteristics (size, income, age) and waste production.
Wertz (1975)			Y	
Johnstone and Lahone (2004)		OECD countries	Y	
Compost				
Allers and Hoeben (2010)		Netherlands	Y	Estimate a price elasticity of -1.77 for compostable waste in the Netherlands.
Linderhof et al. (2001)		Netherlands	Y	Elasticity for compostable waste is 4x that of non-recyclable waste.