The Effect of Recycling on Price Competition: Evidence from the United States Paper Industry

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Abstract

The United States has experienced a dramatic increase in paper recycling starting in the later half of the 20th century. I use panel data, between 1973 and 1993, on paper mills in the US to investigate how this change in recycling affected firm production and prices charged to consumers. I develop a model that separately captures the competing effects of recycling: a pro-competitive increase in total supply that lowers market prices, and an anti-competitive strategic response by incumbent firms aimed at limiting the material available to the future recyclers. I quantify the magnitude of these channels to determine the overall effect while allowing for changes in consumer demand and firm heterogeneity. I use the estimates from the model to simulate alternative environmental policies such as taxes on primary production. I compare the benefits of each policy to the cost of implementation to capture the overall welfare of the policy.

JEL Codes:L13,L14,Q21,Q23

Keywords: Recycling, Input Markets, Dynamic Incentives

1 Introduction

Environmental concerns have led to an increased interest in developing policies to provide incentives for the use of environmentally friendly products. Many of the industries impacted by these policies tend to be highly concentrated. Economic analysis has illustrated that environmental policies can have significant impact on market outcomes when firms possess a degree of market power. For example, Ryan (2012) demonstrated that plant-level emission regulations significantly decreased competition in cement industry. In this paper, I study the effects of policies aimed at addressing concerns about the growth of municipal solid waste facilities (MSW). This

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growth is a concern because MSW facilities can release hazardous materials into the ground-
water and are a point source of greenhouse gas emissions. In response to this concern, states
enacted laws to limit the volume of new materials entering MSW facilities. In particular, these
laws provided subsidies for the purchase of goods made from recycled materials.

An increase in recycling increases the material available as an input for secondary producers.
How effective the secondary sector is at reducing prices was the central question of the American
Company of America (Alcoa) monopolization case. Judge Learned Hand’s opinion rejected the
claim that competition from secondary producers limited the exercise of market power by the
monopolist. The logic of Alcoa ruling has been explored in Gaskins (1974), Swan (1980) and
Martin (1982). These models identify two competing incentives faced by the monopolist. On
one hand, if the monopolist tries to limit production, then the resulting higher price induces the
secondary firms to increase supply. This supply response limits the ability of the monopolist to
raise prices and is the direct, pro-competitive effect of the secondary sector. On the other hand,
the secondary sector relies on the recovered material as an input. The primary producer realizes
that reducing supply in the current period limits how much recovered material is available in
the following period. Thus, there is a strategic, anti-competitive effect because the primary
firm reduces supply to limit future competition. Because the monopolist’s incentives predict
opposite effects on supply and market price, empirical work is needed to determine the total
welfare impact of an increase in recycling.

While the previous literature provides theoretical foundations for the competitive effect of
recycling, several issues remain to address. First, the literature has focused on settings with a
primary good monopolist and a competitive fringe of secondary producers. In contrast, most
empirically interesting settings involve imperfect competition in at least one of the primary or
secondary sectors. Thus, the first contribution of this paper is that I extend the model from
the dominant firm-competitive fringe setting to an oligopoly in both the primary and secondary
sectors. This extension introduces two issues. First, when the primary market is an oligopoly,
each primary producer exerts a negative externality on its rivals. That is, a primary producer
does not take into account the reduction of its rivals’ future profit when setting supply in the
current period. Thus, the total production by the primary sector is likely to be greater under
oligopoly. Second, if the secondary producers behave strategically, then these firms only partially
offset the reduction in supply by the primary sector. This result occurs because the secondary
firms also have an incentive to reduce supply.

My second contribution is that I empirically investigate the effect of government policies
that encourage recycling on final market prices. I exploit changes in state subsidies for the
purchase of paper manufactured from recycled material to study this effect. These policies
provide variation in incentives with both the timing and level of subsidies differing across states.
After recovering parameters of the firms’ decisions problem, I can simulate alternative policies,
such as placing a tax on primary production. Therefore, I also contribute to the literature
exploring the effectiveness of different policy instruments.\textsuperscript{1}

Finally, I contribute to the empirical literature on the link between environmental policies and competition. My empirical setting is the US Pulp and Paper industry. This industry is the third largest industrial energy user in the US, is a major point source of water pollution, and is the primary determinant of demand for timber products. The Environmental Protection Agency (EPA) estimates that producing a ton of paper from secondary, recycled paper, rather than primary, virgin wood, significantly reduces each of these types of environmental damages.\textsuperscript{2}

In this paper, I exploit variation in subsidies designed to shift production towards recycled inputs. Beginning with New York in 1981, states and localities began offering a per-unit subsidy for the purchase of products manufactured from recovered paper.\textsuperscript{3} The share of paper produced in states with a subsidy policy rose dramatically in response, as demonstrated in figure 1. This figure illustrates two trends of interest. First, there are two long periods in which the subsidy policy was unchanged: in the 1970s when no subsidies were in place, and the early 1980s when only New York’s policy is in place. Second, the share of capacity covered increases over time with large jumps when new subsidies are enacted. Finally, these subsidies appear to have the intended effect. The share of paper produced from recycled inputs increased from 21.68% in 1973 to 22.13% in 1981, the first year of any subsidy, and to 30.57% in 1993.\textsuperscript{4} Of course, more careful analysis is needed, and provided later, to disentangle this correlation from causation.

I use annual, mill-level data from the Lockwood Post Directory of Paper, Pulp and Allied Products (LP) from 1973 to 1993 to estimate the model. This industrial source collected data from each paper mill operating in the United States. This data includes paper capacity, mill location, physical assets and final product descriptions. I combine this data with mill-level information collected by the Forest Product Laboratory (FPL). This government source provides the share of mill production that uses recycled inputs. This government source provides novel information that allows me to measure both the mill-level and aggregate amount of secondary products.

The mill-level data is combined with local market data provides information on the recovered paper wholesale market. This information allows me to model the input market explicitly, and close the model. Most of the previous literature has treated the secondary sector as vertically integrated with the recovered wholesale market, an assumption that is not accurate in my empirical setting.\textsuperscript{5} Thus, I also contribute by showing how the vertical relationships between the secondary producers and wholesale market affect competition in the final product market.

\textsuperscript{1}Weitzman (1974) provides an early theoretical exploration of this issue. He focuses on the difference between taxes and standards.

\textsuperscript{2}While the magnitude of the expected gains in the EPA report is likely too high, studies of other industries suggests the direction of the change from increasing the use of recycled materials is correct.

\textsuperscript{3}The list of the timing and magnitude of these policies is included in the appendix.


\textsuperscript{5}Both Gaskins (1974) and Swan (1980) assume the recycling process is vertically integrated. While Martin (1982) allows for non-integration both the secondary producers and recovery sector lack market power, so this is distinguishes is of little consequence.
Table 1: Share of Paper Capacity Covered by State Subsidy over Time

*Note:* Based on author’s calculation using industry information on capacity, government data on mill-level recycling share and state laws.
The rest of the paper is organized as follows. In section 2, I provide a brief review of the literature. Section 3 discusses the theoretical model. I provide a discussion of the data and the industry in section 4. Section 5 discuss the empirical specification. I conclude in section 6.

2 Literature Review

The theoretical underpinnings of the Alcoa ruling have been previously explored in a suite of papers. Gaskins (1974) has the monopolist solve an optimal control problem and shows that price does not converge to marginal costs in the long run. Swan (1980) derives similar results, and he shows that consumers are further harmed if they sell their recycling rather than providing it to the wholesalers for free. Finally, Martin (1982) shows that different assumptions on the vertical relationship between recycling wholesalers and secondary producers changes the equilibrium price but do not drive price down to cost. My theoretical model incorporates the incentives identified in these previous works; however, I extend the model to account for oligopoly behavior. I also explicitly model how subsidies change behavior in the model.

My work is also related to empirical estimates of recycling on market prices. Suslow (1986) estimates the behavior of Alcoa accounting for the supply of secondary aluminum. She documents that Alcoa limited supply as predicted by theory; however, she assumes the supply of secondary aluminum evolves exogenously, so she cannot explicitly capture the strategic incentives. Sigman (1995) examines how different instruments, such as taxes and subsidies, affect recycling in the lead battery industry. However, her work abstracts from strategic interaction between firms.

My paper is also related to the empirical literature on the paper industry. Ohanian (1994) and Melendez (2003) both study determinants of vertical integration in this industry using data from LP. While these determinants are not the focus of this paper, I partially account for the effect of vertical relationships by modeling cost differences between integrated and non-integrated mills. Pesendorfer (2003) focuses on final product competition; however, he investigates whether there are cost synergies from horizontal mergers. My work is different from his in that I explore changes in competition from increases in recycling. The policy changes I use are also more plausibly exogenous than the mergers he uses. Finally, Christensen and Caves (1997) consider an investment game in the paper industry; however, these authors focus on whether announcements of capacity expansion are Cheap Talk. While their messaging game is interesting, I abstract from this issue to focus on how the secondary producers affect final product market competition.

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6This result arises because the monopolist further raises price to capture the increase in consumer demand. Thus, the secondary sector is smaller in this case.

7In a companion paper, I consider the issue of vertical integration explicitly. Similar to this paper, I use the novel information on the use of recycled materials to reconsider the determinants of vertical integration in this industry.
3 Theoretical Model

3.1 Set Up

To study the underlying mechanisms discussed above, I develop a theoretical model of imperfect competition between primary and secondary producers. There are four types of agents in this setting: consumers, primary producers, secondary producers and recycled material wholesalers. Consumers view the final good as homogeneous and have inverse demand for the product given by $P(Q)$.$^8$ P is the market price and Q is the total amount supplied. I assume that the inverse demand curve is decreasing and weakly concave in total supply.

There are $N$ firms that produce the primary good. These firms use virgin material to manufacture the product. I normalize the marginal cost of these firms to zero. There are $M$ firms that produce from secondary inputs. These secondary producers purchase inputs in the market. For simplicity, I will focus on the case in which the only marginal cost faced by the secondary producers is the input price, $r$. This price will be determined in equilibrium by the interaction of the secondary producers and recovered material wholesalers.

Finally, there are recovered material wholesalers that supply this input competitively. These wholesalers collect, sort and transport the recovered material to the secondary producers. There is a natural constraint on this production, as there is a finite amount of recyclable material available in a given period. Thus, the maximum amount of that these wholesalers can supply increases as more material enters the recycling stream.

The primary and secondary producers engage in static Cournot competition in the final product market. The government applies a subsidy, $s \geq 0$, to each unit of the secondary supply sold. At the end of each period $t$, the total amount sold in the period, $Q_t$, is used by consumers and then discarded. A portion of this supply, $\tilde{Q}_{t+1}$ is available to the wholesalers in the following period $t+1$. To simplify the analysis, I assume the recovery technology is perfect, $\tilde{Q}_{t+1} = Q_t$, but the intuition of the model hold if not all supply is recoverable.

3.2 Analysis

I next use the model to generate the empirical implications that are testable with data. To simplify the analysis, I assume that the demand for the final good is given by the linear specification $P(Q) = a - bQ$.$^{10}$

The first step of the analysis is to understand the static competition between the two types

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$^8$Primary paper products were viewed as higher quality in the beginning of the time period I consider. However, the homogeneous assumption illustrates the underlying mechanisms, so I delay the discussion of quality difference to the empirical model.

$^9$The difference between $Q_t$ and $\tilde{Q}_{t+1}$ occurs because some consumers dispose of the good in a manner that makes it impossible to recover, some of the good is too damaged by usage and some consumers hold onto the good for more than one period.

$^{10}$In the empirical specification, I allow the intercept and slope of demand to differ by product category.
of producers. The problem of a primary firm \( n \) is

\[
\max_{q_n} (a - bQ)q_n.
\]

Similarly, the problem for a secondary firm \( m \), for a fixed input cost and subsidy level, is

\[
\max_{q_m} (a - bQ - r + s)q_m.
\]

The solution to this game is given by

\[
q_n = \frac{a + M(r - s)}{b(M + N + 1)}, \quad q_m = \frac{a - (N + 1)(r - s)}{b(M + N + 1)}.
\]

There are several natural comparative statics from this model of competition. First, as the secondary firms become relatively more inefficient, the primary producers represent a greater share of total supply. In order to get a result similar to a dominant firm model in this setting, the secondary firms must be relatively less efficient than the primary producers. This result is also the first piece of information that motivates the exploration of the dynamic channel. If more supply today lowers the input price in the future, then primary produces have an incentive to curtail production. As the subsidy increases, the relative inefficiency of the secondary producers decreases, so their share of supply increases. Thus, the government policy provides an incentive to shift towards secondary supply as intended.

I now turn to an investigation of how the recovery wholesale market affects producer behavior. Again for convenience of demonstrating the result, I assume that competition among the wholesalers generates a liner supply function \( S(r) = (e + dr)\bar{Q} \). This specification assumes that for a given production choice by the wholesalers, the total amount supplied at a given price weakly increases in the amount of recyclable material available. This specification arises if the wholesalers inputs determine the recovery rate of available materials.\(^{11}\)

Under these assumptions, I solve for the equilibrium price in the recovered wholesale market. Aggregating the demand of the secondary producers gives market demand that I equate to the supply function to solve for the equilibrium input price

\[
D(r) = S(r) \implies \frac{M(a - (N + 1)(r - s))}{b(M + N + 1)} = (e + dr)\bar{Q}.
\]

Solving this equation yields an input price of

\[
r = \frac{M(a + s(N + 1)) - b(M + N + 1)e\bar{Q}}{M(N + 1) + dQ}.
\]

\(^{11}\) For example, Swan (1980) assumes that wholesalers solve

\[
\max_z \left[ p\gamma(z) - z - \phi \right] \bar{Q}
\]

where \( \gamma \) is the recovery function, \( z \) is effort and \( \phi \) is the marginal cost paid to owners of the recovered material. This implies that the supply of secondary material is \( s = \gamma(z)\bar{Q} \).
I perform comparative statics on this price to investigate how interaction in the input market affects competition. The key result is that an increase in the stock of recoverable material lowers the cost of the input, and hence the marginal cost of the secondary firms

$$\frac{\partial r}{\partial \tilde{Q}} = \frac{-b(M + N + 1)e[M(N + 1) + d\tilde{Q}] - d[M(a + (N + 1)s) - b(M + N + 1)e\tilde{Q}]}{(M(N + 1) + d\tilde{Q})^2}. \quad (1)$$

Notice that the first term is negative while the second term has the opposite sign as the input price. Under the reasonable assumption that the input price is weakly positive, an increase in the stock of recyclable material leads to a decrease in input price. This result is intuitive, an increase in recyclable material shifts out the wholesale supply function and leads to a lower input price.

While the fact that the mechanism of interest extends from the dominant firm model to the oligopoly model is the primary result from this model, I also provide another result that is intuitive and of interest for the empirical work. First, an increase in the subsidy leads to a higher recovered material price. Thus, the benefit of the subsidy is shared between the secondary producers and the wholesalers. Quantifying the share of the subsidy that goes to each side is interesting given the growing literature on pass-through under different market structures.\(^{12}\) This result also suggests that wholesale recovered input prices will be higher in states with a subsidy.

### 3.3 Extensions

**Preliminary and Subject to Change**

There are two theoretical extensions that I am in the process of finishing. The first is the analysis of the steady state equilibrium. The second is the completion of the extension of the capacity accumulation game original developed in Pesendorfer (2003) for the paper industry.

The steady state analysis is important so that I can compare the results of the oligopoly case to the dominant firm-competitive fringe case in the existing literature. Completing the analysis allows me to test the hypothesis of how imperfect competition changes the results of the literature. The points of interest are whether the negative externality between primary producers weakens the dynamic incentive to curtail production, and whether secondary producers’ market power reduces the the pro-competitive supply response by these producers.

The extension to a capacity accumulation game is important for the empirical setting. Industry sources demonstrate that firms produce at close to full capacity over this time period. This suggests that the dynamic incentive is more likely to come through capacity changes rather than continuous supply adjustments. The intuition of the supply model discussed above, particularly how the incentives affect equilibrium choices, appear to go through. However, the setup of the problem, in particular the interaction between the secondary producers and the recycling wholesalers, requires more care in the capacity accumulation game than in the continuous supply

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\(^{12}\)See Fabinger and Weyl (2013) and the references within for a discussion of this issue.
4 Industry Background

Producers in this industry manufacture two general classes of goods: paper and paperboard products. Paper products include newsprint, office paper and tissue paper while paperboard products include boxboard and linerboard. The goods in each category are relatively homogeneous, see Ince et al. (2001) for a discussion of the similarities and differences both within and across categories. Production takes place in paper mills, which combine heat and pressure to transform the key intermediate input, pulp, into paper. Mill capacity is limited by the number and size of paper machines owned. The cost of installing new capacity is expensive, the average cost per ton of capacity was reported at $1300 per ton in 1986. Because these machines have little use outside the industry, investment in capacity is a sunk cost.

There are two main sources of pulp. The first is virgin wood. Production of this type of pulp involves harvesting timber, and then applying heat and chemicals to produce pulp. The second source of pulp is recovered paper. Recovered paper is collected from households and businesses, and then transformed back into pulp through water and pressure. In the language of the theoretical model, I denote firms using virgin wood pulp as primary producers, and firms using recovered paper as the secondary producers. There are technical difference between these types of pulp that make it nearly impossible to switch between the inputs.

Consistent with the prediction from the model of product market competition, the primary producers have greater capacity on average than the secondary producer. The average daily capacity is approximately 450 tons for primary producers and 125 for secondary producers. These scale differences can also be seen at the aggregate level with primary producers accounting for an average of 82% of annual capacity over the time frame. Consistent with the assumption of greater efficiency for the primary producers, almost all primary production occurs at mills that are vertically integrated into pulp production. This vertical integration is the main source of efficiency advantage for primary producers identified by industry experts.

Differences, such as consumer preferences for quality and production technologies, exist across final product categories. This fact suggests that the degree of competition from the secondary sector also differs across categories. The data are consistent with this hypothesis in both the cross-section and the time series. For example, 21.1% of corrugated medium products were made from secondary inputs in 1975 while only 6.7% of printing paper was. We can see this differences persist over time in figure 1. This figure demonstrates that while both products grow overtime at the aggregate level, the production of primary products is essentially flat for corrugated medium while it continues to grow for uncoated freesheet. These different trends

13In comparison, the most expensive product sold for an average price of $929 while the cheapest at $275 in 1986.
14This result also holds away across the distribution of mill sizes. The likelihood that a given mill will be a primary producer increases as the size of the mill increases.
15Uncoated freesheet is the largest product within the printing paper category. The difference in variables
appear particular strong during the 1980s as the subsidies policies start coming into effect.

There were approximately 900 mills operating in the United States during at least one year between 1973 and 1993. However, the industry trend is one of decline with the number of operating mills decreasing from 809 in 1973 to 664 in 1993. The exit pattern led to an increase in concentration, which when combined with horizontal mergers, significantly increased the scope for market power in this setting.\(^{16}\)

I supplement the industry data with information on the share of recycling production provided by a government source. 77.2% of the mill-year observations can be matched between the two datasets. While there are some observable difference between the mills that can and cannot be matched, it should be noted that most of the unmatched mills produce roofing paper. Roofing paper is quite different from the other products as roofing is sold mainly to the construction industry, instead of households or retailers. Roofing products are also intended for longer life-cycles, so the potential competition from secondary products is on a much different time scale than for other products. Finally, roofing products were closely tied to the asbestos industry, so these firms experienced a negative demand shock not faced by other categories.

<table>
<thead>
<tr>
<th>Product</th>
<th>Share Primary</th>
<th>Share Secondary</th>
<th>Mill Capacity (tons)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coated Freesheet</td>
<td>95.2</td>
<td>4.8</td>
<td>290</td>
<td>660</td>
</tr>
<tr>
<td>Coated Groundwood</td>
<td>100</td>
<td>0</td>
<td>477</td>
<td>363</td>
</tr>
<tr>
<td>Kraft Paper</td>
<td>70.7</td>
<td>29.3</td>
<td>358</td>
<td>597</td>
</tr>
<tr>
<td>Newsprint</td>
<td>75.1</td>
<td>24.9</td>
<td>693</td>
<td>477</td>
</tr>
<tr>
<td>Tissue Paper</td>
<td>38.2</td>
<td>61.8</td>
<td>144</td>
<td>1963</td>
</tr>
<tr>
<td>Uncoated Freesheet</td>
<td>85.3</td>
<td>14.7</td>
<td>266</td>
<td>2172</td>
</tr>
<tr>
<td>Uncoated Groundwood</td>
<td>88.7</td>
<td>11.3</td>
<td>249</td>
<td>334</td>
</tr>
<tr>
<td>Special Paper</td>
<td>90</td>
<td>10</td>
<td>97</td>
<td>1429</td>
</tr>
<tr>
<td>Paperboard</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrugating Medium</td>
<td>44.2</td>
<td>55.8</td>
<td>325</td>
<td>1237</td>
</tr>
<tr>
<td>Linearboard</td>
<td>64.9</td>
<td>35.1</td>
<td>721</td>
<td>1283</td>
</tr>
<tr>
<td>Solid Bleached Board</td>
<td>100</td>
<td>0</td>
<td>718</td>
<td>474</td>
</tr>
<tr>
<td>Recycled Paperboard</td>
<td>0</td>
<td>100</td>
<td>145</td>
<td>3078</td>
</tr>
</tbody>
</table>

*Note:* All calculations at the product level. Share of Vertical Integration, Recycled Paper and Market Pulp calculated from FPL. For approximately 80% of these observations, the mill level and product level are the same. We adjust the remaining observations by using the product share as weights. Forest and Market indicators calculated based on mill location.

Table 2 provides some summary statistics for differences in production at the mill level. For the approximately 20% of mills that produce multiple products, the results are at the product chosen to report comes from the greater degree of aggregation used by the source providing the 1975 figure.

\(^{16}\)A full discussion of the mergers in this industry is provided in Pesendorfer (2003). He documents several mergers of large producers with most of these involving primary production.
category level. Notice that for product categories with a larger share of primary production, the capacity tends to be greater on average. I take this as further evidence of the efficiency advantage of primary production. Also consistent with the discussion that the majority of aggregate production comes from primary producers, almost all the categories have the majority of production coming from primary sources. However, there are several notable exceptions with all recycled paperboard coming from secondary producers and almost 2/3 of tissue paper at secondary producers.

Consistent with the discussion of the theoretical channels, recycling became more common over my sample period. The amount of paper recovered from the waste stream increased from 15.2 million tons in 1973 to 35.5 million tons in 1993 while the tons of recovered paper used as an input in paper mills increased from 14.1 million in 1973 to 28 million in 1993. While the total amount of paper recovered increases in the period after my sample the usage in paper mills essentially flattens.\(^1\) Over this time frame the total supply of paper increased from 65 million tons to 91.6 million tons. Accounting for this growth in demand is important in the empirical analysis. While it seems intuitive growing demand would weaken the incentive to curtail production, all the previous literature has focused on steady state. Thus, the effect of this growth on behavior is an empirical question.

5 Empirical Model

5.1 Descriptive Evidence

I first provide some preliminary evidence that the mechanisms identified in the theoretical model hold in the data. I take the probability that a mill expands capacity as the dependent variable for this analysis. Because capacity utilization was close to 100% over this time period, I treat capacity instead of supply as the strategic variable of interest. I include the log capacity of a mill to control for differences in expansion that arise from scale differences. To account for the effect of recycling on firm behavior, I include an indicator for whether a mill is a secondary producer, whether the mill is located in a state with a subsidy for secondary production in effect and an interaction between these terms.

The hypothesis of interest is that when the pressure from secondary producers increases, the primary producers are less likely to expand capacity. To account for the possibility that there are unobserved variables at the state level that are correlated with capacity expansion I include state fixed effects. I also include year fixed effects to control for time specific unobservables that are correlated with expansion decision. The results of a probit regression on the probability of expanding capacity on these variables is report in column (1) of 5.1.

In the data section, I established that there might be differences across product categories that could lead to different supply responses by the primary producers. To control for these

\(^1\)The divergence is primarily driven by a rapid increase in exports of recovered paper in response to an increase in demand from new plants that opened in Asia.
incentives, I include an indicator to control for the category the mill produces. The results of this specification are presented in column (2) of 5.1. I also explore how more local competition might affect firm behavior. Specifically, I account for the number of secondary producers in the state in which the mill is located. The results of adding the number of secondary producers to my probit regression are reported in column (3) of 5.1.

Several results are interesting from this preliminary work. Secondary producers are less likely to expand capacity if these mills are in a state without a law. In comparison, secondary producers in a state in which these laws are in effect are more likely to expand. These results are consistent with the theory that these laws make the secondary producers stronger competition. Similarly, a primary producer that is in a state with a law in effect, are less likely to expand capacity. This is consistent with the hypothesis that the greater competition from the secondary producers leads to a reduction in supply. However, this simple framework cannot distinguish between a reduction that occurs because of dynamic incentives to limit future competition and a reduction because of a reduction in supply because the producer’s rivals are stronger after the subsidy. Therefore, I need to use further results from the theoretical model to enrich the empirical model to differentiate between these competing hypotheses.

The main results of the models hold after controlling for the product category and the number of secondary producers. The results in column (3) also suggest that primary producers are more likely to expand in states with more secondary producers. This provides some evidence that an increase in the number of secondary producers can strengthen the market position of the primary producers. While this simple model is not rich enough to capture the channel driving this behavior, it seems likely that the increase in secondary firm leads to higher input prices. As discussed in the theory, the higher input price should lead to greater supply by the primary producers. More work on the implications is needed here to distinguish between competing explanations for this effect.

As I complete the theoretical model, these results will be expanded to reflect the other incentives faced by the producers. For example, including demand variables is important to account for the possibility that producers are expanding capacity in response to operating in a larger market.

5.2 Empirical Model

FINAL MODEL IN PROGRESS. UPDATE TO COME AFTER THEORETICAL MODEL IS COMPLETE.

Other definitions of how local the market is can be used. However, there are high transportation costs in the recovered paper sector, so even the state level definition is likely too broad for realism.
### Table: Probability of Capacity Expansion

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log of Paper Capacity</td>
<td>0.19***</td>
<td>0.11***</td>
<td>0.11***</td>
</tr>
<tr>
<td></td>
<td>(0.018)</td>
<td>(0.019)</td>
<td>(0.019)</td>
</tr>
<tr>
<td>Secondary Production</td>
<td>0.041</td>
<td>-0.12**</td>
<td>-0.13**</td>
</tr>
<tr>
<td></td>
<td>(0.041)</td>
<td>(0.062)</td>
<td>(0.062)</td>
</tr>
<tr>
<td>Rec Law in Effect</td>
<td>-0.18**</td>
<td>-0.17**</td>
<td>-0.16**</td>
</tr>
<tr>
<td></td>
<td>(0.074)</td>
<td>(0.076)</td>
<td>(0.077)</td>
</tr>
<tr>
<td>Interaction Secondary and Law</td>
<td>0.25**</td>
<td>0.28***</td>
<td>0.30***</td>
</tr>
<tr>
<td></td>
<td>(0.10)</td>
<td>(0.11)</td>
<td>(0.11)</td>
</tr>
<tr>
<td>Secondary Producers in State</td>
<td>0.031***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>13,005</td>
<td>13,005</td>
<td>13,005</td>
</tr>
<tr>
<td>State FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Product FE</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
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</tbody>
</table>

*Note:*** p<0.01, ** p<0.05, * p<0.1. All standard errors clustered at the mill-level

### 6 Conclusion

I have developed a theoretical model of the effect of secondary producers on product market competition. This model incorporates the insights of the dominant firm-competitive fringe models used by Gaskins (1974) and others to analyze the Alcoa monopolization case. I extend the theoretical model in several ways. First, I allow imperfect competition for both the primary and secondary producers. This modification further shifts producers’ incentives to supply. My theoretical work provides a framework to estimate firms’ strategic incentives.

My theoretical model also allows for a more detailed exploration of the link between the secondary suppliers and recovered paper wholesalers. This interaction closes the model and allows the dynamic incentives to enter the model. The marginal cost of the secondary producers depend directly on this input price, so the secondary producers become more competitive as the input price decreases. An increase in recycling also influences this price, so it is important to account for these changes when estimating the welfare of recycling.

Finally, by accounting for the subsidy, I can study how government policy affects welfare in this market. After I complete the estimation of the model, I will be able to consider the effect of alternative policies, such as taxes on primary production, on welfare in this market.
Figure 1: Difference in Production by Input Used Between Final Produce Categories

Appendix

State Recycled Paper Laws during Time Period

<table>
<thead>
<tr>
<th>State</th>
<th>Price Preference</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>AZ</td>
<td>5%</td>
<td>1990</td>
</tr>
<tr>
<td>AR</td>
<td>10%</td>
<td>1991</td>
</tr>
<tr>
<td>CA</td>
<td>5%</td>
<td>1989</td>
</tr>
<tr>
<td>GA</td>
<td>8%</td>
<td>1991</td>
</tr>
<tr>
<td>ID</td>
<td>5%</td>
<td>1985</td>
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<td>10%</td>
<td>1989</td>
</tr>
<tr>
<td>MD</td>
<td>5%</td>
<td>1988</td>
</tr>
<tr>
<td>MI</td>
<td>10%</td>
<td>1989</td>
</tr>
<tr>
<td>MN</td>
<td>10%</td>
<td>1989</td>
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<td>10%</td>
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<td>5%</td>
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<td>NM</td>
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<td>1981</td>
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<tr>
<td>WV</td>
<td>10%</td>
<td>1989</td>
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References


