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Recycling, International Trade, and the Distribution of Pollution: The Effect of Increased U.S. Paper Recycling on U.S. Import Demand for Canadian Paper

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ABSTRACT

The quantity of paper recycled in the U.S. has more than doubled since 1985. International trade theory predicts that this will lead to reduced imports of paper, and a shift in domestic production toward waste paper intensive outputs (e.g., newsprint) and away from higher grade products such as printing/writing paper. Import demand elasticities with respect to input prices were estimated for newsprint, printing/writing, and all paper utilizing 20 years of monthly data. The empirical results confirm the predictions of theory, and illustrate a channel through which recycling may be more beneficial for U.S. industry than the domestic environment.

Key Words: import demand, paper industry, pollution, recycling.

One of the most apparent impacts of the American environmental movement is the dramatic increase in recycling. Only 10 years ago, curbside recycling programs were rare in the United States, but now they are a regular part of waste management in most communities. Many economists have been skeptical of the value of recycling, suggesting that the pollution from recycling trucks and value of time spent sorting and collecting offset any benefits accruing from reduced waste disposal. Some economists have even suggested that paper recycling reduces the number of trees, by reducing the incentive of paper companies to grow them (Wiseman). This study raises additional economic issues about paper recycling

that environmental advocates have failed to consider.

Although it has a large domestic paper industry, the U.S. historically has been a net importer of paper products. Because of the size of its domestic economy, an increase in recycling rates results in a large increase in the amount of waste paper available to industry. In contrast, Canada, the primary trading partner of the U.S. in paper products, has a small consumer economy relative to its paper industry, so that a similar increase in recycling rates has a much smaller impact on the availability of raw materials to industry. Basic international trade theory suggests that increased U.S. recycling will result in more domestic production of paper, and reduced Canadian imports. Rybczynski's theorem states that a rise in the endowment of one factor relative to the other will increase the output of the good using that factor intensively relative to the other good

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(Vousden). Thus, Rybczinski's theorem implies that greater recycling will result in a long-run shift of the U.S. paper industry toward the production of waste paper intensive outputs (e.g., newsprint) and away from higher grade products such as printing/writing paper.¹

A casual inspection of U.S. paper import data conforms to the above hypothesis. The past decade has seen a reduction in U.S. net imports of paper, most of which can be accounted for by large reductions in imported newsprint from Canada. The ratio of U.S. production to U.S. consumption for newsprint increased from 0.35 in 1970 to 0.54 in 1994. However, the ratio for printing/writing paper decreased from 0.99 to 0.87 during the same period (American Forest and Paper Association 1995). Imports of printing/writing paper—which, along with newsprint, accounts for most U.S. paper consumption—have been increasing, while newsprint imports have decreased. This is in line with expectations; however, a more careful analysis of the data is required before concluding that these changes have been caused by greater recycling.

Estimates of import demand elasticities with respect to exchange rates, income, and output and input prices can help explain the causes of these changes in trade patterns. In addition to exchange rate effects, U.S. import demand could be affected by changes in domestic supply caused by changes in relative input prices. Waste paper prices in the U.S. have fallen dramatically over this period, and may explain some of the shift in imports. Since over 90% of U.S. paper imports are from Canada (Uhler, Townsend, and Constantino), most of the shift in aggregate import demand for paper should be captured by an empirically simpler focus on bilateral trade between the two countries. Therefore, this paper estimates the U.S. demand for aggregate Canadian paper imports as well as import de-

Table 1. Paper Recovery and Waste Paper Utilization, Selected Years 1970–94

Year	Recovery Rate (%)	Utilization Rate (%)
1970	22.4	22.8
1975	24.2	23.0
1980	26.7	23.5
1985	26.8	23.8
1988	30.5	25.1
1991	36.7	29.1
1994	40.3	32.9

Source: American Forest and Paper Association

mand for newsprint and printing/writing paper from Canada.

The next section of this paper briefly chronicles the recent rise in U.S. paper recycling. This is followed by a discussion of the theoretical and empirical considerations in estimating trade elasticities, drawing heavily from a survey article by Goldstein and Khan (1985). The final sections discuss estimates of U.S. import demand elasticities for Canadian paper from 20 years of monthly data between 1976 and 1996, and their implications for U.S. recycling policies.

The Increase in U.S. Paper Recycling

In the mid-1980s, solid waste suddenly moved to the forefront of America's environmental concerns. As the nation watched the saga of the "garbage barge" from New Jersey that couldn't find a home, and cities struggled to locate sites for new landfills, Americans became extremely interested in recycling. The U.S. has consistently recovered and recycled approximately 25% of its paper consumption since World War II, but the last decade has seen a dramatic increase in the paper recovery rate. The increase in paper recovery rates, combined with continued growth in paper consumption, means that the amount of recovered paper available for production has nearly doubled in 10 years—increasing from about 20 million tons in 1985 to 39 million tons in 1994. As shown in table 1, the waste paper utilization rate has increased more slowly than

¹ In 1989, about 25% of the fiber used in U.S. newsprint production was waste paper, whereas waste paper accounted for only 6.7% of printing/writing papers' pulp input (American Paper Institute).

the recovery rate as industry adjusts its capital to take advantage of this new input source.

The increase in paper recovery in large part is due to an increasing number of cities offering curbside recycling programs, and various other types of policies that have raised public awareness about recycling and the ease of accomplishing it. For example, there were 11 times as many curbside recycling programs in the U.S. in 1995 than in 1988, increasing from around 500 to over 7,000 programs (Goldstein). Economists may wonder whether this increase in the quantity recycled is just a result of higher prices for recycled products. However, as waste paper prices dropped in the late 80s and early 90s, waste paper recovery continued to rise, and more and more communities added recycling programs without regard to whether there was a market for the recovered materials. As the recovered material piled up in warehouses, some cities actually paid to have their recycled paper taken away (Wise-man).

U.S. Import Demand for Canadian Produced Paper

Most empirical trade studies are based on one of two general models, the imperfect substitutes model and the perfect substitutes model (Goldstein and Khan 1985). As the name implies, the imperfect substitutes model assumes that imports or exports are not perfect substitutes for one another, and trade depends on price differentials between domestic and foreign goods. The perfect substitutes model assumes that foreign and domestic goods are perfect substitutes internationally traded at a common price (net of transportation costs).

The appropriate model to use depends upon the good in question. In general, the imperfect substitutes model is appropriate for studies of aggregate imports (exports) and highly differentiated consumer goods, whereas the perfect substitutes model is used for trade in primary, homogeneous commodities. For example, the imperfect substitutes model would be appropriate in studying domestic and imported beer, but the perfect substitutes model is suitable for studying domestic and imported copper. Paper

is a primary commodity produced to common specifications for use in consumer products. Therefore, the perfect substitutes model is appropriate for this study of U.S.-Canada paper trade, while the imperfect substitutes model may be appropriate for trade of printed material.

In the perfect substitutes model, import demand and export supply functions are the "excess" demand and "excess" supply of domestic goods. Only domestic prices of goods are necessary, which simplifies data collection and eliminates the potential measurement error problems when countries have different methodologies for collecting price statistics. A simple model of import demand for good i is specified as:

$$(1) \quad D_i = f(P_i, \mathbf{Y}),$$

$$(2) \quad S_i = g(P_i, \mathbf{F}),$$

$$(3) \quad I_i = D_i - S_i,$$

where D_i , S_i , and I_i are the quantity of good i demanded, supplied, and imported, respectively, by the home country; \mathbf{Y} is a vector of demand shifters such as income, and \mathbf{F} is a vector of supply shifters such as input prices. The main implications of this model come from the derivation of the price elasticity of import demand, η_{ip} :

$$(4) \quad \eta_{ip} = (1/S)\eta_p - (1 - S/S)\epsilon_p,$$

where η_{ip} is the price elasticity of demand for imports, η_p is the price elasticity of domestic demand for the good, ϵ_p is the price elasticity of domestic supply, and $S = (I_i/D_i)$ is the share of imports in the domestic quantity demanded of good i . Thus, the price elasticity of demand for imports is positively related to the absolute values of domestic demand and supply elasticities, and negatively related to the share of imports in domestic demand.

As noted earlier, imports are a much greater share of U.S. newsprint consumption than is the case for printing/writing paper. Therefore, if we assume the domestic supply and demand elasticities of newsprint and printing/writing paper are equal, the price elasticity of import

demand for printing/writing paper should be significantly larger than the elasticity of import demand for newsprint. Even if the assumption of identical supply and demand elasticities is dropped, there is a wide enough disparity in the import shares for the two commodities that larger (in absolute value) import elasticities should be expected for printing/writing paper. In addition, note that expressions similar to equation (4) could be derived for input prices, income, and the real exchange rate as well, so the empirical results should show elasticities with respect to all these variables to be larger for printing/writing paper than for newsprint.

From the above model, a reasonable specification of per capita U.S. import demand for Canadian paper would use the U.S. price of paper, U.S. input prices (pulpwood and waste paper), per capita income, and the Canada-U.S. real exchange rate as independent variables. The price of paper should have a negative impact on imports in all three models (total paper, newsprint, and printing and writing), and per capita income is positively related to domestic demand for all three dependent variables which corresponds to a positive impact on import demand as well. An increase in the real exchange rate expressed in Canadian dollars per U.S. dollars makes Canadian goods relatively less expensive than U.S. goods, meaning import demand should be positively related to the real exchange rate. The effect of a change in pulpwood and waste paper prices is less clear, and is likely to have different short-run and long-run effects as well as differ between newsprint and printing/writing paper.

In the short run, an increase in input prices has a negative impact on domestic supply, which translates into a positive change to import demand. In the long run, changes in input prices could affect investment, which would have impacts on domestic supply and import demand. In the case of paper, U.S. prices of waste paper have dropped relative to wood pulp, giving U.S. paper companies the incentive to invest in more waste paper intensive industries such as newsprint. Thus, a decrease in the price of recovered paper may have a

Table 2. Expected Long-Run Relationship Between Model Parameters and Import Demand for Total Paper, Printing/Writing Paper, and Newsprint

	Total Paper	Printing/Writing	Newsprint
Own-Price	—	—	—
Wood Pulp Price	?(-) ^a	+	?(-) ^a
Waste Paper Price	+	?(-) ^a	+
Income	+	+	+
Real Exchange Rate (Can \$/U.S. \$)	+	+	+

^a Indicates opposite short-run and long-run effects. The long-run effect is expected to dominate and is given in parentheses.

negative long-run impact on domestic supply of printing/writing paper and a positive impact on domestic newsprint production. This supply change corresponds to a negative long-run relationship between waste paper prices and import demand for printing/writing paper (opposite the short-run effect) and a positive relationship between waste paper prices and import demand for newsprint, reinforcing the positive short-run effect. Similarly, increases in the price of wood pulp (relative to waste paper) could also encourage investment in waste paper intensive newsprint production, and cause similar long-run effects on import demand. Because newsprint accounts for more Canadian imports than printing/writing paper, the effect of input prices on total paper import demand will likely reflect the newsprint effects. Table 2 gives a summary of the expected long-run relationships between the model parameters and import demand for total paper, printing/writing paper, and newsprint. Possible endogeneity of input and output prices is discussed in the next section.

Econometric Issues

As the adjustment of imports to the explanatory variables will not be instantaneous, the econometric model must incorporate some type of lag structure. The simplest technique is the "Koyck" distributed-lag model with geometrically declining weights. The primary

weakness of this model is that it assumes the greatest effect of any change to the explanatory variables occurs in the first period—a strong restriction, particularly for changes in input prices whose effects should not be felt for several periods. Polynomial lag models do not impose a uniform lag pattern on all the explanatory variables. This study uses a second-order polynomial distributed lag (PDL) model because it allows for both the geometrically declining effect of the “Koyck” model, as well as an initially increasing effect followed by a period of decreasing effect or inverted “V” shape. In addition, the second-order PDL conserves degrees of freedom that would be used in estimating the additional parameters in a PDL of higher order. The lag length is determined by picking the model with the minimum Akaike Information Criterion (AIC).

Simultaneity of the own-price variable is less of a problem in estimating import demand than ordinary demand, because many small importers face import supply functions that are horizontal at the world price (Chacholiades). However, for many goods, the United States is a large importer that faces an upward-sloping export supply, and single-equation estimation of demand will result in biased coefficients. Because inputs are traded between the two countries, input prices may also be endogenous in this model. If endogeneity is a problem, determinants of Canadian export supply, such as Canadian GNP, could be used in an instrumental variables procedure. Another option is to explicitly specify a model of import supply in addition to import demand, and to simultaneously estimate the entire system with maximum-likelihood techniques (Goldstein and Khan 1978). Further research on this topic will certainly address this potential simultaneity bias.

Data

The data consist of a 20-year monthly time series from September 1976 to September 1996. Data on U.S.-Canada imports and exports and producer price indexes for input and output prices were obtained from monthly is-

sues of *Statistics of Paper, Paperboard, and Wood Pulp* published by the American Forest and Paper Association. Monthly data on exchange rates, U.S. and Canadian GDP, population, and price indexes were obtained from the International Monetary Fund's (IMF's) monthly publication, *International Financial Statistics*, and Federal Reserve Economic Data (FRED), a World Wide Web site maintained by the Federal Reserve Bank of St. Louis.

Imports and GDP are divided by population, eliminating or reducing a potential source of heteroskedasticity. All prices are deflated by the domestic producer price index for all goods, and the real exchange rate is calculated using U.S. and Canadian consumer price indices. Wholesale prices generally are preferred for calculating real exchange rates, but only a consistent monthly time series of Canadian consumer prices was readily available from the IMF reports for the entire sample period. As the U.S. and Canadian economies are thought to be very similar in terms of their relative prices of traded and nontraded goods, the use of consumer prices is unlikely to be very problematic in this case. All variables except monthly dummies are expressed in logs.

Empirical Results

The models were estimated with various combinations of lag lengths for the regressors (with the exception of the monthly dummies), varying the lag lengths in six-month intervals. For each model, the lag specification which yielded the lowest AIC statistic was chosen. Table 3 presents the long-run effects of lagged variables in the import demand estimation, with the number of monthly lags utilized for each variable shown in parentheses.² As would be expected, adjustments due to changes in input prices seem to take longer than responses to output price and income. The long lag re-

² Because of the very long lag lengths, a full appendix showing estimated coefficients for the full lag structure of all the independent variables and monthly dummies would be enormous, and thus is not included in the paper. The detailed tables of the estimated parameters for all variables included in the model are available from the author upon request.

Table 3. Total Long-Run Effects of Lagged Variables in Import Demand Estimations

	Total Paper	Printing/Writing	Newsprint
Own-Price	-1.514 (18)	-2.949 (24)	-1.795 (18)
Wood Pulp Price	-0.306 (30)	3.146 (36)	-0.879 (30)
Waste Paper Price	0.126 (30)	-1.032 (36)	0.476 (30)
GDP per Capita	2.070 (18)	6.882 (24)	1.481 (18)
Real Exchange Rate (Can \$/U.S. \$)	0.121 (30)	2.929 (24)	0.444 (30)

Note: The number of monthly lags appears in parentheses.

sponse of real exchange rates is more difficult to understand, but is a common finding in studies of this type (Goldstein and Khan 1985).

Table 3 shows the total effect over all periods (long-run elasticity). All the long-run elasticities in table 3 are of the expected sign and have *F*-statistics significant at the 95% level. In addition, printing/writing paper imports are more elastic than newsprint with respect to all of the explanatory variables. This coincides with the result in equation (4) that the import share of a commodity is inversely related to its import demand elasticities.

Discussion and Conclusion

The empirical results closely follow expectations. Printing/writing paper imports are more elastic than newsprint due to their smaller import share. There is evidence that the recent shift toward increased imports of Canadian printing/writing paper and decreased imports of newsprint are related to changes in the decrease in waste paper prices relative to wood pulp. Looking at an aggregate of all paper products, lower waste paper prices appear to have resulted in lower imports of Canadian paper.

The analysis would be greatly improved by considering additional factors. The simultaneity issues are discussed earlier, and need to be accounted for in further analysis. In addition, several policy events (NAFTA, and recycled content laws) should be incorporated into the model. Newsprint and wood pulp have always been traded tariff-free between the U.S. and Canada, but small U.S. tariffs on imported printing/writing paper (about 3.5%) have been

gradually eliminated due to NAFTA. While these tariffs were small, they may explain some of the increases in printing/writing paper imports. In addition, about 20 U.S. states have passed some type of minimum recycled content for newsprint guidelines since 1990. As these laws are considered to be practically unenforceable and largely symbolic, it is doubtful they have had important impacts on newsprint imports.

While these industry shifts are of economic interest, they also have implications for environmental policy. This paper suggests that one result of increased recycling is greater domestic production of paper, and as a consequence, an increase in domestic industrial pollution. In essence, the U.S. is exporting "saved trees" to Canada, and importing manufacturing plants and pollution. Of course, this is just one effect of paper recycling, so it should not be interpreted to mean that U.S. paper recycling is bad for the U.S. environment when all factors are taken into account (e.g., fewer landfills). However, in a time when many environmental issues are portrayed as "jobs versus the environment," this paper illustrates at least one channel through which domestic recycling is more beneficial to domestic jobs than it is to the domestic environment.

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