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Does Quality Matter in the Iron and Scrap Trade?

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Abstract

This paper sheds light on the iron and steel (IS) scrap trade to examine how economic development affects the quality demanded of recyclable resource. A simple model is presented that show a mechanism of how scrap quality impacts the direction of trade due to comparative advantage. We find that economic development in both importing and exporting countries has a positive effect on the quality of traded recyclables. Developed countries that intend to improve the domestic recovery of recyclables should raise the quality of separating recyclables while developing countries should tighten environmental regulations to help decrease the import of recyclables that cause pollution.

Keywords: iron and steel, scrap, environment, trade

JEL classification: F18, O13

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Introduction

Utilizing the urban mine, which refers to various metals contained in electrical or construction scraps, has attracted much attention in national policy debates as waste metal recycling could improve resource efficiency. In recent years especially, price hikes in natural resources due to increasing demand in emerging countries have led to a higher demand for scrap as a substitute. Generally scrap is exported from developed countries, where it is discarded in relatively large volumes, to developing countries with high resource demand. Dahlstroem and Ekins (2006) estimate that the UK exports 4,818kt of scrap iron and steel, which was equivalent to 33% of the country's iron and steel production in 2001; and they show that these exports have been increasingly significant. Similarly, Japan exported 6,447kt of IS scrap in 2007 mainly to Asian countries.

In resource-poor developed countries such as Japan, the increase in scrap exports has given rise to debate over how to efficiently utilize the urban mine within the country. On the other hand, developing countries seek ways to import better quality recyclables to reduce pollution in the process of recycling. Although a large volume of IS scrap is exported to developing countries, some is exported to developed countries. This fact leads to an expectation that imported and exported IS scrap differs in quality, otherwise trade does not occur. Indeed, we observed from customs statistics that prices of traded IS scrap vary significantly depending on trading partners. For example, in 2007 a unit value of IS scrap (HS7204) exported from Japan to the US was 10 times higher than the IS scrap exported to China. This raises the question of whether higher quality IS scrap is exported to developed countries, and what factors determine the direction of trade for IS scrap of different qualities.

The purpose of this paper is to examine the relationship between the quality of traded IS scrap and economic development. We will describe the characteristics of the IS scrap trade and show that the previous literature dealing with trade relations and the quality of general goods is not well suited to explaining the pattern of the IS scrap trade. Therefore we have develop a simple theory to show how the quality of traded IS scrap is affected by the income and environmental regulations of the countries trading. Based on our theoretical model, our hypothesis will be tested using panel data for worldwide bilateral trade from 1990 to 2007.

Recycling policy has intended to emphasize the improvement of resource efficiency and has not paid much attention to the quality aspect of recyclables. Our analysis shows that the quality of recyclables should be taken into account in recycling policy because countries with differing endowments have different comparative advantages depending on the quality of recyclables. Scrap utilization in a developed country might improve were there to be an increase in the domestic supply of higher quality IS scrap. Developing countries need to tighten the enforcement of environmental regulations in order to reduce pollution from the recycling process that tends to utilize lower quality scrap.

The paper is organized as follows. Section 1 presents our review of previous studies and shows how IS scrap differs from the cases examined in those studies. In section 2 we develop a simple theoretical model to show how the direction of the IS scrap trade is determined. In Section 3 we set forth our methodology of statistical analysis. Our results are presented in Section 4. Finally, the policy implications we draw from our study are presented in the conclusion.

1. Survey of the Literature

As we observed in the trade of higher quality IS scrap, the findings in the literature on trade also show that higher quality goods are exported to developed countries[1]. Countries with different income levels have intra-industry trade because the quality of goods produced as well as the quality demanded varies among countries. Flam and Helpman (1987) focused on vertical product differentiation and showed in their theoretical study that developed countries export higher quality goods while lower quality goods are produced in developing countries. In their empirical studies, Schott (2004), and Hummels and Klenow (2005) found the relationship between quality and trade by focusing on the supply-side effects. Hallak (2006) examined trade and quality by arguing that consumers in higher income countries demand higher quality goods. Schott (2008) found a pattern of specialization within products in the trade between China and the OECD by using the export price as a proxy for quality and suggests that the patterns of trade between China and the OECD countries show significant vertical specialization.

However, the mechanism of the IS scrap trade differs in two respects from the ones suggested in previous studies. First, IS scrap is not a good produced by firms and second, IS scrap is not a final good that consumers demand but an input for intermediate goods, which is iron and steel. Because IS scrap has special features distinct from other goods, we would like to highlight the relationship between the quality and direction of trade in IS scrap. IS scrap as a recyclable has features distinct from other goods. Firstly, it is not a commodity produced by firms but is a resource discarded after use. This

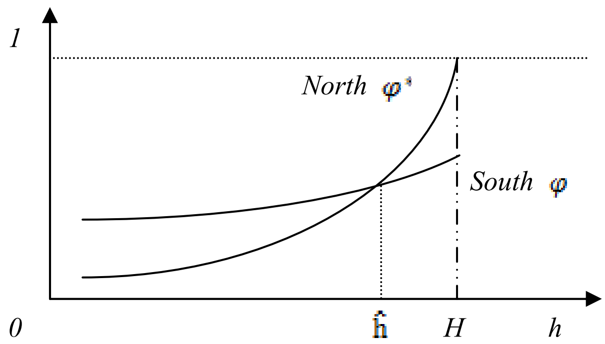
[1] The literature on quality and trade usually deals with a variety of products together with quality issues.

means the behavior of firms as IS scrap producers is irrelevant unlike the argument of previous studies that have focused on the supply side. Second, IS scrap is neither a consumption good nor an intermediate good but rather an input for intermediate goods. IS scrap is an input used in electric furnaces to make steel products which are intermediate goods. Based on these characteristics, we will develop a model for the IS scrap trade.

2 Model for Quality and Trade Direction

This section presents a partial equilibrium model for an IS scrap recycle firm. In the model there are two countries, North and South. The North is denoted by an asterisk. We assume there is a single type of recycle firm in each country. The recycle firm uses labor l and IS scrap S to produce crude steel R. The crude steel can be produced from IS scrap separated into different qualities, which is usually observed in steel production. IS scrap is heterogeneous in quality and we refer to South IS scrap quantity S_h and productivity φ_h of scrap variety h where $h = 1{\sim}H$ and $\varphi \in (0,1)$. The like terms for the North are IS scrap quantity S_h^* and productivity φ_h^* of variety h. Figure 1 presents the assumptions about φ_h. We assume that the separation of IS scrap by quality is higher as h increases. As the rate of recovering crude steel from different qualities of IS scrap depends on the technology of each country, we assign different productivity to each country, i.e., φ_h and φ_h^* to the South and North respectively. Machine processing is more productive for well separated scrap, therefore higher φ_h is expected for higher h in the North where capital endowment is higher. Scrap that contains plastic, other metals and so on requires manual separation work, therefore the labor-abundant South has a comparative advantage. In sum, the North has the higher productivity in the higher quality IS scrap while the South has the higher productivity in the lower quality IS scrap,.

Figure 1: Productivity φ in the North and South



The firm production function for the South is a Cobb-Douglas form where $\beta \in (0,1)$.

$$R = l^{\beta}(\varphi_h s_h)^{(1-\beta)} \qquad (1)$$

We denote the price of crude steel, wages, and the price of h quality of IS scrap by p, w and γ_h, respectively. Crude steel is internationally traded, therefore p is the international price[2] while the IS scrap price γ_h is the local price. We assume higher quality scrap h has a higher price γ_h, therefore γ_h increases as h increases. As higher quality scrap has higher productivity, $\partial R/\partial \varphi > 0$. By solving the profit maximization problem for the southern firm, we obtain the unit cost function as follows:

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[2] In this two-country model, the crude steel price is given as we assume the IS recycle sector does not affect the crude steel price in both the North and the South.

$$p = \left(\frac{w}{\beta}\right)^{\beta}\left(\frac{\gamma_h}{\varphi_h(1-\beta)}\right)^{1-\beta} \qquad (2)$$

In the same way, we obtain the unit cost function for the North. By taking the ratio and rearranging the terms, we obtain equation (3).

$$\frac{\gamma_h}{\gamma_h^*} = \left(\frac{w^*}{w}\right)^{\frac{\beta}{1-\beta}}\left(\frac{\varphi_h}{\varphi_h^*}\right) \equiv A_h \qquad (3)$$

Equation (3) shows that for a given scrap variety, IS scrap prices differ between the North and South and that the IS scrap of a given variety is exported to the country with the higher price. The price difference is attributed to the difference in wages as well as productivity between the North and South.

This gives us the following rule of trade direction.

$\text{variety h is exported to the North if } A_h < 1$

$$\text{variety h if exported to the South if } A_h > 1$$

If northern wages, or w^*/w, increase, the South could offer a relatively higher price for the IS scrap, and γ_h/γ_h^* would increase, in which case the South would import the IS scrap. Similarly if northern productivity is higher for h quality, φ_h/φ_h^* decreases. For quality h, the North becomes more competitive in importing IS scrap. Therefore, A_h is decreasing in h. We set h=$\hat{h}$ where A=1. If h>$\hat{h}$, the North imports the h-quality IS scrap; if h<$\hat{h}$, the South imports the h-quality IS scrap. This simple model explains how higher quality IS scrap is exported to higher income countries.

Effects of Environmental Policy

Based on the basic model, we will look at the effects on the IS scrap trade of environmental regulation and trade costs such as that for shipping. With τ as the environmental tax regulating environmental pollution emitted while processing IS scrap, then:

$$p - \tau = \left(\frac{w}{\beta}\right)^{\beta} \left(\frac{\gamma_h}{\varphi_h (1-\beta)}\right)^{1-\beta} \quad (4)$$

$$\frac{\gamma_h}{\gamma_h^*} = \left(\frac{w^*}{w}\right)^{\frac{\beta}{1-\beta}} \left(\frac{\varphi_h}{\varphi_h^*}\right) \left(\frac{p-\tau}{p-\tau^*}\right) \equiv A_h(\tau, \tau^*) \quad (5)$$

The higher environmental tax τ^* in the North relative to the South where

$\tau < \tau^*$increases $A_h(\tau, \tau^*)$ which would enable the South to import IS scrap in a wider range of qualities compared to the case where $\tau = \tau^*$. Suppose the environmental tax in the North τ^* increases while that in the South remains unchanged. Then A_h increases and the higher environmental tax in the North leads to an increase of varieties of IS scrap exported to the South.

3 Methodology

This study employs a gravity type hedonic price model. Gravity models seek to explain the determinants and direction of bilateral trade flow between home and partner countries. The theory of this formulation is based on its resemblance to the law of gravity. Applying this to trade, gravity models imply that trade flow increases with the size and closeness of the trading partners. An early explanation of this came in the study by Linneman (1966), which utilized a partial equilibrium model of export supply and import demand. Anderson (1979) utilized a trade share expenditure system and utility maximization. Bergstrand (1985), on the other hand, pointed out that the gravity equation is a reduced form of the general equilibrium demand and supply systems. The theoretical foundations based on the Heckscher-Ohlin Theorem have also been utilized by Deardorff (1997) and Evenett & Keller (1998), and it has been found that the H-O framework produces results like those predicted in gravity equations. In the H-O model, the larger the differences in factor endowments between two countries, the larger the trade. In reality, however, the trade between developed countries that have similar factor endowments is higher. Yet, if high-income consumers have higher budget shares for capital-intensive goods, then capital rich countries trade more with other capital rich countries (Markusen, 1986). Thus, the predictions of the gravity model are confirmed. As a matter of fact, there are three types of trade models: those based on technology differences in trade such as Ricardian models, those using variations in factor endowments as in H-O models, and those based on increasing returns as in increasing-return trade models (Evenett & Keller, 1998). Although technology and factor endowments are different across countries, they can vary over time and can be transferred between countries. Early empirical studies were done by Tinbergen (1962) and Poyhonen (1963). Some studies utilized cross-sectional data (Aitken, 1973; Bergstrand, 1985; Oguledo & Macphee, 1994; Porojan, 2001) while others used panel data (Zhang & Kristensen, 1995; Matyas et al., 2000; Egger, 2002–2004; Carrere, 2004; Martinez-Zarzoso & Novak-Lehmann, 2004). Some recent studies (Anderson & van Wincoop, 2003; Baier & Bergstrand, 2007) have develop methods that consistently and efficiently estimate the theoretical gravity equation.

Hedonic price models are widely used for valuating commodities and products. The theoretical development of these models was the work of Lancaster (1966), Griliches 1971), and Rosen (1974). This study uses the gravity parameters together with the hedonic price model to examine the factors that determine the quality of IS scrap traded bilaterally. Following Schott (2004), we regard unit values of IS scrap (traded value/quantity) as quality to examine how IS scrap quality determines trade[3].

In the empirical estimation of the model, we employ a gravity type hedonic price model, in which the price of IS scrap traded bilaterally is used as a dependent variable. The panel regression run in this study is specified as:

$$lnuv_{ijt} = \beta_0 + \beta_1 lngdp_{it} + \beta_2 lngdp_{jt} + \beta_3 lnuvr_t + \beta_4 lnd_{ij} + \beta_5 qr_{it} + \beta_6 qru_{jt} + u_{ijt} \quad (6)$$

where,

uv: unit value (US$ price) of IS scrap categories traded between partner countries.

gdp_i: GDP per capita of reporting (exporting) country, in constant US dollars

gdp_j: GDP per capita of partner (importing) countries, in constant US dollars

uvr: Iron ore unit value, in US dollars

d: Distance between most populous cities in reporting and partner country, km.

qr_i: Quality of regulation index for reporting country

qr_j: Quality of regulation index for partner country.

Data Description

We use bilateral trade data from UN Comtrade (2010), which is reported in the

3 Although many studies use price (or unit value) of traded goods as a proxy for quality, others have sought to show that unit value can reflect various effects other than quality. For example, Verhoogen(2008) and Goldberg and Pavcnik(2007) have examined the income effects.

Harmonized System (HS) classification code at the six-digit level. IS scrap is recorded under the HS7204 code, and IS scrap is further classified into 6 commodities as shown in Table 1. The data set spans 18 years from 1990 to 2007. The income data is drawn from Penn World Tables 6.3 (2010). The descriptive statistics of the data used in this study are presented in Table 2. There are a few cases where scrap is traded at quite a low price or without charge thus yielding close to zero minimum unit values.

Table 1: HS Code Categories for IS scrap (7204)

720410	Waste or scrap, of cast iron
720421	Waste or scrap, of stainless steel
720429	Waste & scrap of alloy steel other than stainless steel
720430	Waste & scrap of tinned iron/steel
720441	Waste from the mechanical working of iron or steel nes
720449	Ferrous waste & scrap (excl. of 7204.10-7204.41)

Table 2: Descriptive statistics (1990-2007)

	Min	Max	Mean	Std Dev	No obs
Uv(10)	0.2E-4	21.488	7.9	301	5.992
Uv(21)	0.9E-3	1.429	2.1	25	9.018
Uv(29)	0.4E-5	17.880	5.9	215	7.842
Uv(30)	0.4E-4	73.333	19.8	1.081	4.624
Uv(41)	0.9E-4	529.567	113.6	7.677	4.759
Uv(49)	0.2E-4	112.365	18.9	1048.9	12.106
gdp_i	602	88.321	18.928	12.896	6.080
gdp_j	314	88.321	18.347	13.808	6.080
uvr	26.5	84.7	44.8	21.4	6.080
d	115	19.650	4228	4249	6.043

qr_i	-2.1	2.0	0.57	0.87	3.248
qr_j	-2.3	2.0	0.53	0.91	3.252

4 Results

The model is estimated utilizing the panel data over the period of 1990-2007 for 287 countries and six different IS categories. The results are presented in Tables 3 and 4. Because of high collinearity between the GDP per capitas and quality of regulation indices, two separate regressions were run. The panel estimation results reported include both the random effects model (REM) and fixed effects model (FEM). The Hausman Specification test favors the FEM except for category 720421. However both estimations yield similar results. As can be seen, GDP per capita of the reporting and partner countries are positive and significant indicating that higher income levels lead to higher prices for IS scraps. The parameter of the iron-ore unit value is positive and significant indicating that the price increase in iron ore is reflected in the scrap unit value. Distance is a proxy for the transportation cost, and as was found, high transportation cost leads to an increase in unit value. Regarding the quality of regulation, both the home and partner countries have positive and significant effect on the unit value. That finding highlights that better regulation result in better quality scrap being traded between the countries. The coefficients of the home country regulations are generally higher than those of the partner countries. This can be attributed to the fact that regulations in exporting countries increase the cost of IS scrap trading which increases the unit value of the scrap exported.

Table 3. Scrap Quality Panel Regression Results (Dependent Variable LN-Unit Value)

	REM								FEM				
Codes	Constant	Lngdpc-r	Lngdpc-p	Ln-unitvr	Lndist	R^2	N	HS	Lngdpc-r	Lngdpc-p	Ln-unitvr	R^2	N
720410	-8.51	0.31***	0.11***	0.45***	0.17***			25.78***	0.75***	-0.067	0.48***		
	(0.40)	(0.028)	(0.027)	(0.036)	(0.025)	0.10	5984		(0.18)	(0.15)	(0.05)	0.10	5984
720421	-8.31	0.24***	0.14***	0.84	0.08***				0.30***	0.14***	0.83***		
	(0.81)	(0.052)	(0.01)	(0.02)	(0.01)	0.18	9007	1.36	(0.09)	(0.01)	(0.030	0.18	9007
720429	-9.01***	0.27***	0.22***	0.53***	0.14***				0.51***	0.21***	0.48***		
	(0.45)	(0.04)	(0.01)	(0.03)	(0.01)	0.11	7834	9.98**	(0.14)	(0.01)	(0.04)	0.10	7834
720430	-8.74***	0.38***	0.10***	0.49***	0.10***				0.18	0.07	0.61***		
	(0.42)	(0.02)	(0.02)	(0.04)	(0.02)	0.13	4623	15.59***	(0.23)	(0.2)	(0.06)	0.08	4623
720441	-9.08***	0.31***	0.10***	0.57***	0.20***				0.87***	0.09***	0.43		
	(0.70)	(0.07)	(0.02)	(0.04)	(0.01)	0.09	4748	20.79***	(0.16)	(0.02)	(0.06)	0.05	4748
720449	-9.37***	0.33***	0.09***	0.65***	0.18***				0.67***	0.13	0.58***		
	(0.32)	(0.02)	(0.02)	(0.02)	(0.02)	0.12	12091	20.27***	(0.10)	(0.10)	(0.03)	0.07	12091

***, **, * significant at 1, 5, 10 % respectively; standard errors are in parentheses.

Table 4. Scrap Quality Panel Regression Results (Dependent Variable LN-Unit Value)

	REM								FEM				
Codes	Constant	Ln-unitvr	Lndist	qreg-r	qreq-p	R^2	N	HS	Ln-unitvr	qreg-r	qreq-p	R^2	N
720410	-4.71***	0.54***	0.12***	0.39***	0.13***				0.50***	0.38***	0.13***		
	(0.30)	(0.05)	(0.02)	(0.04)	(0.03)	0.10	3216	6.89*	(0.05)	(0.03)	(0.03)	0.08	3216
720421	-4.73***	0.88***	0.08***	0.26***	0.20***				0.89***	0.08	0.19***		
	(0.35)	(0.05)	(0.02)	(0.07)	(0.03)	0.18	4668	9.86**	(0.05)	(0.21)	(0.03)	0.16	4668
720429	-4.74***	0.57***	0.11***	0.34***	0.27				0.57***	0.17	0.26***		
	(0.39)	(0.06)	(0.04)	(0.07)	(0.03)	0.12	4049	11.98**	(0.06)	(0.24)	(0.03)	0.12	4049
720430	-4.94***	0.62***	0.08***	0.51***	0.18***				0.68***	0.77***	0.14		
	(0.30)	(0.05)	(0.02)	(0.03)	(0.03)	0.16	2584	4.78	(0.06)	(0.28)	(0.28)	0.15	2584
720441	-4.99***	0.55***	0.17***	0.14	0.12***				0.53***	0.41***	0.12***		
	(0.60)	(0.12)	(0.03)	(0.11)	(0.04)	0.07	2347	10.24**	(0.12)	(0.30)	(0.04)	0.06	2347
720449	-5.19***	0.62***	0.14***	0.38***	0.10***				0.62***	0.38***	0.10***		
	(0.02)	(0.04)	(0.02)	(0.02)	(0.02)	0.10	6337	2.81	(0.02)	(0.02)	(0.02)	0.10	6337

***, **, * significant at 1, 5, 10 % respectively; standard errors are in parentheses.

Conclusion

During the past decades an increasing amount of recyclables has been exported from developed to developing countries. Although developed countries have accumulated a large stock of scrap in their urban mine, and have sought to improve the domestic utilization of this accumulation, domestic recycling has not been very successful. This paper has addressed the question how the North could improve the utilization of its urban mines, and how the South and North could specialize in recycling. We examined the trade of iron and steel scrap and found that IS scrap quality affects the direction of trade. A simple theoretical model was presented to explain how IS scrap of a lower quality of separation tends to be exported to the South due to comparative advantage.

Our empirical results support this hypothesis, and we found that the quality of traded IS scrap is positively correlated with the incomes of importing countries. This result suggests that developed countries could increase the domestic recycling of their urban mine if they increased the quality of scrap separation . Improvement in the quality of separation could be achieved through changes in product designs that make recycling more efficient with machinery and through improving collection schemes.

The quality of traded IS scrap is positively correlated with the income of exporting countries. We learned from the regression results that higher income countries produce higher quality recyclables. This is probably because the larger production scale in developed countries results in producing a larger amount of homogeneous, well-separated scrap. And another reason could be that scrap includes a variety of used machinery which is discarded more in developed countries, and this might be reported as scrap but be used as second-hand goods illegally.

We also assessed the impact of environmental policy. Tighter environmental regulation in scrap importing countries helps importers obtain a higher quality of scrap separation. This result is consistent with the current situation in Asian countries where recycling is often conducted in the informal sector. As recycling scrap of lower separation quality emits various residues which cause pollution, tightening environmental regulation in developing countries helps decrease such pollution-intensive processes. Stricter regulation in exporting countries also raises the quality of traded IS scrap. This could be due to higher income countries having better collection systems.

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