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Procedia CIRP 61 (2017) 172 – 176

www.elsevier.com/locate/procedia

The 24th CIRP Conference on Life Cycle Engineering

Uncertainty Analysis of Global Reuse Monitoring

Kohei Endo[a], Masaaki Fuse[a,*]

[a]*Hiroshima University,1-4-1 Kagamiyama, Higashi-Hiroshima 739-8527, Japan*

* Corresponding author. Tel.: +81-82-424-7826; fax: +81-82-424-7826. *E-mail address:* masa-fuse@hiroshima-u.ac.jp

Abstract

Global reuse monitoring traces the international trade of used products, which is the first step toward global reuse management. This study aims to analyze the uncertainty of global reuse monitoring by focusing on the mirror statistics issue in the trade data for used automobiles and engines. Our uncertainty analysis clarifies the high uncertainty in the trade of used products at the inter-country level. In addition, it notes that the outliers and missing values affect this uncertainty to a large extent. The correction of the outliers and missing values to accurately reflect the characteristics of trade statistics is essential for global reuse monitoring.

Peer-review under responsibility of the scientific committee of the 24th CIRP Conference on Life Cycle Engineering

Keywords: International trade; used products; trade statistics; mirror statistics issue; outlier; missing value

1. Introduction

In today's global economy, the lifecycle of a product is not always restricted to one country. The second lifecycle of the product starts from the crossing of national boundaries for reuse elsewhere. This is called global reuse [1,2]. Global reuse offers several benefits to the importing countries [3], while also causing possible environmental impacts due to their substandard reuse system [4]. Global reuse management for controlling such economic and environmental impacts is one of the hot topics in life cycle engineering. Global reuse management first needs to monitor international trade for used products. As the powerful tool of global reuse monitoring that trace trade of used products, there is trade statistics compiled by each country. This information is available in the trade statistics for some products and/or countries [5-11]. Trade statistics, however, are characterized by a specific uncertainty, traditionally known as the mirror statistics issue, which point out the discrepancies between the two records of the exporting and importing country in a bilateral trade [12]. Many studies for have been conducted for analyzing the uncertainty in trade statistics at the industrial level [13-24]; however no studies have analyzed trade uncertainty with a focus on used products.

The objective of this study is to analyze uncertainty associated with global reuse monitoring by delving into the mirror statistics issues of available trade statistics for used products. The contents of this paper are as follows. Section 2 refers to the trade statistics employed for the uncertainty analysis. In section 3, the uncertainties of global reuse monitoring are quantified from the discrepancies associated with trade statistics for used automobiles and engines. Section 4 examines how the uncertainties identified in section 3 can be corrected. In the last section, the findings from this study are summarized.

2. Trade statistics for uncertainty analysis of global reuse monitoring

The uncertainty analysis addressed in this study needs the inter-country trade data for used products as reported by the trade statistics for each country. The data availability of the trade of used products from trade statistics depends on the item classification, which is uniquely defined by the reporting country [25]. The previous works show that the data on the trade of certain used products (e.g., automobiles and home appliances) and/or countries (e.g., the US, Japan, the EU

Peer-review under responsibility of the scientific committee of the 24th CIRP Conference on Life Cycle Engineering
doi:10.1016/j.procir.2016.11.150

countries, and Peru) is available [5-11]. With a focus on used automobiles and engines, the trade data for this uncertainty analysis were obtained from the Global Trade Atlas (GTA) that provides the original trade data on trade statistics for 86 countries [26]. The UN Comtrade provides data on trade statistics for countries around the world. The data are basically integrated for new and used products using the internationally standardized item classification [27].

Table 1 summarizes the obtained trade data. Our analysis targets five product types (gasoline engines, diesel engines, buses, passenger cars, and trucks). The trade data covers values, shipments, and weights at the inter-country level for the period 2004 to 2013. In global reuse monitoring, the information on the shipments of used products in trade statistics is used. Table 1 states that the 86 countries targeted in the GTA do not always feature used products in their item classification. Concerning used engines, data availability is limited to 44–47 countries out of the 112–121 countries reported by the UN Comtrade. Furthermore, the data availability for used automobiles is limited to 25–28 countries out of the 121–131 countries. Although trade statistics are useful as a tool of global reuse monitoring, their coverage to the trade of used products is not always comprehensive and changes according to product types.

Table 1. Trade data for uncertainty analysis[1]

Used product		HS code[2]	Reporting country[3]
Engine	Gasoline engine (G engine)	840734	44/112 countries
	Diesel engine (D engine)	840820	47/121 countries
Automobiles	Buses	870210, 870290	25/121 countries
	Passenger cars (Car)	870321, 870322, 870323, 870324, 870331, 870332, 870333, 870390	27/131 countries
	Trucks	870410, 870421, 870422, 870423, 870431, 870432, 870490	28/131 countries

[1]The trade data covers values, shipments, and weights at the inter-country level for the period 2004 to 2013. [2]HS code indicates the item classification internationally standardized by the United Nations [27]. [3]The denominator is the number of reporting countries that have the item classification for used products and the numerator is the number of reporting countries as per the UN Comtrade.

3. Quantifying uncertainty of used product trade

In this study, the uncertainties associated with the trade of used products are assessed based on the discrepancies in trade statistics triggered by the mirror statistics issue. The discrepancy can be described as the gap between the records of the exporting country and the corresponding records of the partner importing country. A large gap in bilateral trade indicates that the trade is characterized by high uncertainty. On the other hand, no gap could mean that the trade data is highly accurate. Hence, in order to quantify the uncertainties associated with the trade of used products, the gaps in all bilateral trades for reporting countries (Table 1) are evaluated by drawing up a scatter plot as shown in Fig. 1. This figure is an example of a scatter plot to evaluate the gaps in bilateral trade. Each plot in Fig. 1 represents shipments reported by the exporting and importing countries, respectively. As indicators of the gap evaluation, this study focused on the slope (a) and determination coefficient (R^2) of the following regression analysis without a constant term that fits the scatter plot.

$$SM_{ijkt} = a_k \cdot SX_{ijkt} + u \quad (1)$$

where SM_{ijkt} is the shipments reported by importing country j from partner country i for used product type k in year t; SX_{ijkt} is the shipments reported by exporting country i into partner country j for used product type k in year t; u is the error term. As the values of the indicator a and R^2 comes care lose to 1, it is evaluated that the gaps in all bilateral trade come are close to 0.

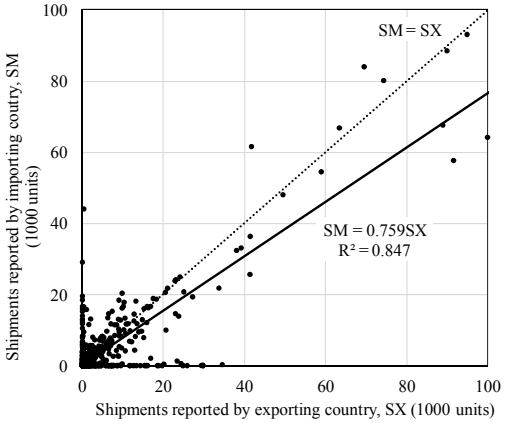

Fig. 1. Example of a scatter plot to evaluate gaps in bilateral trade

The evaluation results for the gaps in the bilateral trade for the target used products from 2004 to 2013 are shown in Table 2. Focusing on the total shipments for gasoline and diesel engines in Table 2, the gaps in bilateral trade are seemingly small. However, because the estimates for a and R^2 of both engines were 0.31–0.51 and 0.094–0.37, respectively, the gaps in the individual bilateral trades were evaluated as large. The estimates for a and R^2 of buses and trucks were 0.013–2.1 and 0.001–0.002, respectively, indicating that the bilateral trade for used buses and trucks exhibits a large gap. Although the estimate for a of passenger cars was 0.89, which is relatively close to 1, the estimate for R^2 was 0.026, much farther from 1. A large gap in the bilateral trade for used passenger cars was noted.

Thus, the gap evaluation mentioned above indicates that the trade data for used automobiles and engines generally exhibits high uncertainty.

Table 2. Evaluation results for gaps in shipments in bilateral trade for target used products from 2004 to 2013

Used product	Samples[1]	Exports[2] (1000 units)	Imports[2] (1000 units)	a	R^2
G engine	2420	40,534	36,140	0.505	0.370
D engine	2829	45,249	37,471	0.310	0.094
Buses	954	88	343	0.013	0.001
Cars	2742	4,938	10,037	0.885	0.026
Trucks	2693	1,003	19,113	2.076	0.002

[1]Samples refers to the bilateral trade count that is the same as the sample count of the scatter plot. [2]Exports refer to total shipments by exporting countries. [3]Imports refer to total shipments by importing countries.