Ecological Economics 132 (2017) 245–254

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

China-USA Trade: Indicators for Equitable and Environmentally Balanced Resource Exchange

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ARTICLE INFO

Article history:
Received 9 August 2016
Received in revised form 12 October 2016
Accepted 6 November 2016
Available online 15 November 2016

Keywords:
Equitable trade indicators
Emergy
China-USA trade
Resources use indicators

ABSTRACT

Trade needs to be evaluated by more comprehensive indicators that complement market-based economic value. The Emergy Accounting (EMA) method proved to be a valuable tool to help address trade complexity by means of environmental quality-oriented indicators. EMA is used in this paper to evaluate the environmental and resource flows involved in China-United States (USA) trade in the years 1993, 2000 and 2008. Results show that China emergy exports (i.e. exports of raw and less processed resources) exceed the imports from USA. Although the money received by China from exports is higher than the money paid for imports, the real imbalance relies in the huge amount of resources that outflow from China, hardly compensated by the value of imports in terms of support to Chinese economy. The conclusion is that trade accounting methods should include holistic valuations beyond the financial costs of traded goods. Policy implications of these results are discussed.

1. Introduction

Trade globalization has led to international economic integration that systemically links nations, and plays an important role in affecting sustainable economic development and ecological dynamics amongst nations (Jomo and Rudiger, 2009; Lin et al., 2014). Increasing attention to the environmental impacts of international trade has been in the spotlight for years (Copeland and Taylor, 2013). Increased international trade increases energy and material costs while generating global air, sea and land environmental burdens. Not only globalized trade may generate new environmental problems, but it also increases resource imbalance amongst trading countries, with developed countries gaining cheap access to primary resource imports from developing ones (WTO, 2011).

After China's entry into the World Trade Organization (WTO), economic integration became even more global, with even more evident ecological implications. As the world's manufacturer, China supports its export production by consuming its natural resources and releasing vast amounts of pollutants (Liu et al., 2015). Such heavy nature–economy interplay in China has resulted in environmental degradation (Fu et al., 2007). WTO development and Chinese economic growth arrived with commensurate environmental developmental issues. The concern is still evolving and current. Evidence of this is that USA and Pacific Rim countries are coming to terms with the Trans-Pacific Partnership trade agreement, and environmental sustainability is a major barrier to approval in the USA.[1] Post-colonial and mercantilist theories have espoused the economic disadvantages associated with imbalanced trade especially to developing countries (Alderson, 1998). Trade may be balanced in monetary terms. But, the sole use of economic valuations to evaluate trade provides an incomplete picture of the trade balance. In particular, primary resource imports generally benefit developed economies translating into uncompensated loss of domestic natural resources within exporting countries (Proops et al., 1999;Feenstra, 2015).

The increasing evidence of imbalanced trade has resulted in several methods to account for direct and indirect consumption of resources, environmental impacts, and the role of ecosystem services in human-dominated economies (Odum, 1996; Wackernagel and Rees, 1998; Joshi, 1999). Input–Output Analysis (IOA), Ecological Footprint (EF) and EMergy Accounting (EMA) are among the most comprehensive methods to gain in-depth understanding of imbalance and environmental costs. IOA is mainly used to account for the complex interdependencies of various economic sectors based on sectorial monetary transaction data, and identify both direct and indirect environmental burdens from consumption perspective (Wiedmann et al., 2007). IOA is applied to evaluate a variety of flows in trade, such as carbon or pollution emissions (Peters et al., 2011), virtual water (Hoekstra and Hung, 2005), embodied materials (Bruckner et al., 2012), and embodied energy (Machado et al., 2001). However, due to the fact that IO tables are usually available only at larger scales, and the updates of IO tables are not constant, the suitability of IOA at micro levels of products,

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[1] http://www.nytimes.com/2014/01/15/us/politics/administration-is-seen-as-retreating-on-environment-in-talks-on-pacific-trade.html

http://dx.doi.org/10.1016/j.ecolecon.2016.11.008
0921-8009/

processes and regions is limited and insufficiently detailed (Dong et al., 2016). As for EF, this method addresses the environmental carrying capacity of nations, and provides an easily understood and acceptable picture by the general public and policy makers (Wackernagel et al., 2006). However, it is often criticized for inaccuracy and uncertainty, for not addressing technology improvement and also for its limited boundary (Geng et al., 2014).

In order to set the foundation for improved research and discussion on international trade benefits and costs, the Emergy Accounting method and its supply-side perspective of value are used in this study to complement the conventional monetary accounting (Ulgiati and Brown, 2012). EMA provides an estimate of the total biosphere work supporting natural and human-made systems and helps understand the overall network of interactions between economic processes and environmental dynamics. The interest in emergy accounting of economies is growing as witnessed by a large number of published papers, such as Lomas et al., 2008-Spain; Gasparatos and Gadda, 2009-Japan; Lei et al., 2012-Macao and Sweden; Giannetti et al., 2013-Brazil; Lou and Ulgiati, 2013-China; Zucaro et al., 2014-Italy; etc, dealing with economic performance and development of countries worldwide. EMA-based evaluations have been performed for macroeconomics of states and nations (Brown and Ulgiati, 2004; Jiang et al., 2007; Siche et al., 2010; Yang et al., 2010;Geng et al., 2013; Lou and Ulgiati, 2013) and the microeconomics of industrial parks (Geng et al., 2010; Taskhiri et al., 2011; Liu et al., 2012; Tian et al., 2014), but very few studies have been published about trade between nations (Odum, 1996; Brown, 2003; Fan, 2012). The present study on China- USA trade between 1993 and 2008 by means of the emergy evaluation technique aims to provide a different although complementary perspective and outcome for trade balance between two major trade players worldwide. The basic policy and research questions are: while China seems to have a satisfactory trade balance in economic terms, who are the real beneficiaries in the China-USA merchandise trade when the embodied environmental quality of traded resources comes into play? Considering that monetary assessment does not fully capture the environmental support and losses related to production for export (natural capital depletion, soil erosion, diversion of environmental services, additional environmental costs generated by air pollution, etc), how should such supply side losses be included in trade accounting? These questions are answered in this study within a broader bio-physical perspective, in so highlighting the added value of coupling the emergy approach to monetary evaluations.

After this introductory section, methods and data sources are presented in Section 2, including the past trends of economies between China and the USA, the EMA approach and the main statistical and scholarly data sources referred to in this study. Results of EMA-based China-USA trade assessment are shown in Section 3. Section 4 presents further analysis of results and discusses the policy implications. Finally, Section 5 draws the research conclusions.

2. Methods and Data Sources

2.1. The Economies of China and the USA

China entered the WTO in 2001 and has experienced historically large increases in international trade. The gross value of China's total foreign trade increased from 1.32 USD trillion in 2001 to 8.23 USD trillion in 2012, corresponding to 43.1% and 51.8% of its GDP, respectively (WorldBank, 2013a). China mainly exports industrial goods, especially mechanical and electrical products, while mainly importing high-tech products. China is the largest exporter and second largest importer in the world.

The USA as the world's largest economy is characterized by a foreign trade increase from 2.42 USD trillion in 2001 to 4.94 USD trillion in 2012 (about 22.8% and 30.4% of its GDP, respectively) (WorldBank, 2013b). The USA international trade has the greatest export to import deficit, with imports much greater than exports. The main exported goods include high-tech and agricultural products. Currently, the USA is the second largest exporter and the largest importer in the world.

Table 1 summarizes Chinese imports from and exports to the USA in the years 1993, 2000 and 2008. The selection of these three years is mainly due to data availability and a rational time gap. Imported and exported items are grouped into five main categories: fuel, metals, minerals, food and agro-products, and industrial products. Food and agro-products are the highest economically valued import category, with grain representing about 80% of the total in 2008. Exports are dominated by industrial products with glass representing about 70% of the total in 2008.

Industrial products represent the category with the largest trade volume between the China-USA Within industrial products, machinery and transport equipment is the largest subgroup, accounting for 65% and 60% of the 2008 total import and export trade volumes, respectively. All exported items show an increasing trend over time. This increasing trend is true for imported items other than minerals and industrial products. The trade volumes of both China imported and exported items show an increasing trend. Exports to the USA are much larger than imports from the USA in terms of goods and monetary trade volume. China's imported goods volume had an almost three-fold, nearly 300% increase between 1993 and 2008. China's exported goods volume increased about 1600% during this same period. China's imported monetary volume increased about 700% between 1993 and 2008, while the exported monetary volume increased about 1500%.

2.2. The Emergy Accounting Approach

The Emergy Accounting (EMA) approach is an environmental evaluation tool used to assess the contribution of natural resources to economic activities (Odum, 1996; Brown and Ulgiati, 2011; Geng et al., 2013; Lou and Ulgiati, 2013; Pan et al., 2016) by means of environmentally-oriented indicators. EMA focuses on biosphere system metabolism. It takes into account: (1) nonrenewable energy and material resources usage (2) renewable flows of solar radiation, wind, rain, and geothermal activity, and slow renewables such as soil organic matter and ground water (3) the indirect environmental support embodied in human labor and services (L&S).

EMA's basic concept is the solar emergy, defined as the total amount of available energy (exergy) of the solar kind, directly or indirectly required to generate a given product or service. Emergy uses solar emjoules (sej) as unit of resource flows (Odum, 1996). The emergy required to generate one unit of each product or service is referred to as its Unit Emergy Value (UEV) or emergy intensity. In particular, UEVs are named *transformities* if the unit emergy cost is expressed as sej J^{-1} and *specific emergies* if the unit of sej g^{-1} is used. The more generic term of *emergy intensity* may also be defined using time (e.g.: sej hr^{-1}), area (e.g.: sej m^{-1}), or economic value (e.g.: sej $\$^{-1}$) units.

Raw data of mass, energy, labor, and money flows are converted into emergy units by using appropriate UEVs and then summed into the total amount of emergy (U) supporting a given system. UEVs measure how much biosphere activity was required to produce a unit of good or service over its entire supply chain. The higher the UEV of a good or service the greater the environmental work necessary to produce it.

Three main steps are followed to perform an EMA. First, the investigated system (in this study, the trade bilateral relation) is represented through an energy system diagram using a systems diagramming language (Odum, 1996). This systems diagram shows the interacting systems and their exchanged flows of energy and money. Second, all matter, energy, and money flows are listed as trade inventory and multiplied by their respective UEVs to convert them into emergy units (sej). When appropriate, the emergy supporting the indirect labour and services needed to extract, process and trade resources is included. The emergy of Labor and Services (L&S, Table 2) is an important additional assessment, because it includes both the direct activity performed