1.0 Introduction

With the expansion of international trade over the past century, the importance of business-to-business relationships in determining environmental outcomes of market activity has grown monumentally. Increased inter-dependency among corporate actors in the processing, manufacturing and distribution of products has led to more disciplined supply chain relations which, when taken as a whole, increasingly mimic the governance systems of corporations themselves. Direct and explicit attention to the structure of such relations promises to be an important element of effective environmental management within the context of global commodity chains.

China’s high manufacturing, consumption and trade volumes, combined with its heavy dependency on imports for supplying its manufacturing base, give global commodity chains a special importance as strategic instruments for reducing ecological impacts of both Chinese and global economic activity.

The “Product Chain Analysis” project outlines a series of activities designed to assess the ecological impacts and shared responsibilities of China and its trading partners in several commodity supply chains. This document provides a brief overview of research methodologies related to the project, some of the outstanding methodological challenges and a proposed analytic framework for carrying the work forward.

2.0 Overview of Related Methodologies

The objective of the Product Chain Analysis project is to determine the social and environmental impacts of Chinese supply chain activity in specific commodity sectors with a view to facilitating effective sustainability management of commodity supply chains at the global level. The commodity chain approach to assessing sustainability impacts, or “global commodity chain sustainability analysis” (GCCSA), suggests a unique approach to policy development and correspondingly, the need for the adoption of a unique methodology. Although the commodity chain sustainability analysis approach is novel in its own right, three existing research methodologies bear direct relevance on the main issues of importance to such an approach and therefore warrant explicit consideration: life-cycle analysis (LCA); global commodity chain analysis (GCCA); and ecological footprint analysis (EF).

2.1 Life-cycle Analysis
Life-cycle analysis (LCA), a product of the natural sciences, attempts to measure all of the environmentally relevant inputs and outputs with respect to the processes related to the production, use and disposal of a given product. One of the distinctive characteristics of the LCA approach is the breadth of product/environment relationships examined. While different actors are potentially implicated at different stages of the analysis, LCA, first and foremost, links environmental impact to products, with the perspective of market behaviour along the various stages of the product life cycle and in making decisions between products.

A full LCA typically consists of four steps:

**Goal definition:** A definition of the “service” provided by the product is identified as a benchmark for comparison across products. For example, the goal definition for LCA with respect to a heater might be “maintaining ambient air at 21°C for one hour.”

**Inventory analysis:** The core of the LCA consists of a technical inventory analysis which consists of gathering data on all of the environmental inputs and outputs during extraction, cultivation, processing, transportation, manufacturing, use and disposal. Inventory analysis is made in terms of the defined goal to provide comparability and tends to be complex.

**Impact assessment:** The results of the inventory analysis of environmental impacts are classified in terms of recognized environmental themes (e.g., biodiversity, global warming, human toxicity, desertification, etc.).

**Valuation:** The impacts, on the basis of the different environmental themes, are weighted enabling comparison across different products.

Life-cycle analysis arguably provides the most comprehensive analysis of the productive cycle of any research methodology. Its attention to environmental impacts while products pass through different hands, enables a global assessment of product impacts which is difficult to achieve through other means, and which is particularly appropriate to a study of the environmental impacts of commodity chains. Life-cycle analysis does, however, face many important challenges: 1. the technical complexity and costliness of full LCA which significantly limits its overall use; 2. the difficulty (or subjectivity) in comparing performance values along different environmental themes; and 3. its tendency to assume that products are “static” entities with fixed environmental impacts. Finally, LCA’s lack of attention to market structure, market power and the underlying policy framework means that an LCA on its own, provides only limited information on what the appropriate market or policy tools for improving environmental performance might be.

### 2.2 Global Commodity Chain Analysis

Global commodity chain analysis has its basis in theoretical political economy and focuses on the role of power relations and supply chain structure in determining market outcomes. More formally, GCCA refers to the systematic study of commodity chains and seeks to explain the spatial organization of production, trade and consumption of the globalized world economy. A commodity chain in this context is seen as “a network of labour and production processes whose result is a finished commodity.” Specific processes within a commodity chain are represented as “nodes” linked together in networks. Under the rubric of the GCCA, commodity chains are described as “a set of inter-organizational networks clustered around one commodity or product,” in which networks are situation-specific, socially constructed and locally integrated. Reflecting its attention to social and economic relations, GCCA has relied heavily on characterizations of commodity chains as being either “producer-driven” or
“buyer-driven”. A GCCA typically includes an investigation of following four core elements of the chain:

*Input-output structure:* The input-output structure refers to the nature of products which are supplied to the chain, the transformations they undertake as they move through the chain to the final products produced.

*Territory:* The territory of the chain refers to geographical regions within which specific processes and chain relationships occur.

*Governance structure:* The governance structure identifies the nodes and networks that are operational along a supply chain as well as the social/power relationships they entail.

*Institutional framework:* The institutional framework refers to institutions which technically reside outside the commodity chain specifically, but influence the actions taken along the supply chain (e.g., governmental policy).

The GCCA’s attention to the social and economic relationships along supply chains provides a critical basis for the development of strategic market-based and regulatory policy by allowing targeted application of policy to the commodity chain context. The principal challenge facing rigorous application of GCCA is that many of its most important concepts, such as “power,” are difficult to frame in discrete quantitative terms. As a result most assessments tend to be qualitative, making consistency and comparability difficult to ensure. Applications of GCCA also have a history of oversimplifying complex supply chain relationships by framing them in terms of a producer/consumer dichotomy which overlooks key elements of decision-making authority shared among different segments of the supply chain.

### 2.3 Ecological Footprint Analysis

The Ecological Footprint (EF), developed in Canada by Mathis Wackernagel and Willam Rees during the 1990s, provides a methodology for measuring environmental impact of economic activity as a function of geographic area. The foundation of the footprint approach is built on a comparison of the resource demand of a particular area or population with corresponding resource availability. Typically the footprint methodology involves translating resource use into a quantitative estimate of the “land area” required to supply such resources. The rationale for such analysis stems from the acknowledgement that the planet has finite physical resources, or “bio-capacity,” and that effective environmental management requires market and policy decisions that reflect the limited bio-capacity of the planet.

Although, in principle, a wide range of variables can be converted into “land use” equivalents, it is also clear that not all environmental variables are appropriately captured by such equivalents. In practice, EF calculations have relied on a very select range of variables to allow for wide applicability and use. The main variables used in calculating EF at the national level, using the “compound method”\(^1\) are; food consumption; timber consumption; carbon storage requirements; building and road development; and biodiversity needs. The EF can also be used to assess the land use requirements associated with sub-national populations or

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\(^1\) The compound method consists of using raw trade data to calculate national consumption along the key variables.
“resource users” through the application of the “component method.” The component methodology is more flexible and potentially more accurate, but considerably more costly.

On the basis of one of the above methodologies, the analyst calculates the demand for land in area units or the “ecological footprint” of a nation or population. The difference between the footprint and the supply of land (the actual bio-productive area controlled by the population measured in area units) is termed the “ecological deficit” and is one of the key statistics reported by the EF methodology. The EF methodology can also be applied to “non-living” resource users, such as products and firms. In such cases, the primary “output” of the analysis will be a ranking of land use, based on the subject of analysis.

Beyond its conceptual appeal, the strength of the EF approach lies in its ability to link environmental impacts with global carrying capacity and its ability to attribute degrees of responsibility to primary resource users (both according to geographic and institutional location). As such it provides clear global targets for policy intervention. However, if simplicity is the strength of the EF analysis, it is also its greatest weakness. The objective of converting economic activity into its land area usage equivalent, necessarily leaves many environmental impacts under-reported. Pollution and water usage, for example, are typically not factored into EF analysis. As such, the EF approach has limited use as a tool for measuring overall environmental impacts, serving primarily as a tool for mobilizing awareness and action regarding over-consumption.

3.0 Extracting a Methodology for Global Commodity Chain Sustainability Analysis

The starting point for an analysis of the environmental impacts of commodity chains as a whole must be attentiveness to each of the stages of the commodity chain in the analysis. In this respect, the LCA approach arguably offers the most comprehensive and adaptable methodology to the commodity chain context. Although the LCA normally applies single products, the basic methodology is transferable to the different stages of the commodity chain. Since the direct objective of the analysis is neither to develop a measure of China’s EF as a whole, nor to develop a ranking of the EF of different commodity chains, but rather to develop targeted policy approaches for managing environmental sustainability of trade, the LCA approach to measuring impacts would appear to be most appropriate to the given context.

Similarly, given the principal interest in identifying techniques for leveraging commodity chains towards improved environmental sustainability, information on the social and economic relations will be critical. The GCCA, being specifically directed at assessing such relations thus holds particular promise in this regard. However, at the same time, it is equally clear that quantitative data on the trade flows and environmental impacts of specific practices along the supply chain will be a pre-requisite of effective environmental management.

Meanwhile, China’s dual role as a major consumer and a major manufacturer for export, suggests that the responsibility for the impacts of supply chain activities of which China is a part, ultimately must be shared by China and its trading partners together. Responsibility can be distributed on the basis of actual consumption volumes (geographic or population-based), market position and/or legal jurisdiction. Ultimately, effective policy will depend upon responsiveness to each of these sources of responsibility and authority. A key challenge facing the development of effective policy depends upon linking the distribution of responsibility with appropriate leverage points for change along commodity chains. The EF

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2 The component method relies on local data including direct interviews and typically assesses a wider range of variables in order to extract energy and direct land use requirements which are then calculated into land area units.
methodology, through its reliance on indicators of consumption, provides the most explicit
direction for allocating shared responsibility and thus offers the most insight on how
responsibility might be attributed along commodity supply chains.

Following these observations, we can extract the following basic analytic framework for a
Global Commodity Chain Sustainability Analysis (GCCSA):

| An Analytic Framework for Conducting a Global Commodity Chain Sustainability Analysis |
|-----------------------------------------------|-----------------------------------------------|
| Subject                                      | Possible Elements                         | Possible Methodological Guidance |
| 1.0 Policy Framework                         | National and international policy         |                                |
|                                              | Public and private policy                 |                                |
| 2.0 Supply and Demand Statistics and Trends  | Compilation of China’s production, import and export |                                |
|                                              | Assessment of use for domestic consumption and China’s use for export | EF compound analysis |
|                                              | Analysis of future market trends          |                                |
| 3.0 Social and Environmental Impacts         | Identification and ranking along the entire supply chain | LCA, perhaps EF component analysis |
|                                              | Distinction between China’s use for domestic consumption and China’s use for export (tracing the major destinations and related environmental impacts) | EF compound analysis; other social analysis |
| 4.0 Supply Chain Structure                   | GCCA                                         |                                |
| a. institutional structure                   | Basic structure of the supply chain; nodes and networks |                                |
|                                              | Timeline of supply chain life cycle        |                                |
|                                              | Analysis of horizontal and vertical integration |                                |
| b. market power                              | Relative market share of actors            |                                |
|                                              | Gross revenues of actors                  |                                |
|                                              | Sourcing patterns/options of actors        |                                |
|                                              | Barriers to entry or market access facing different actors, anti-competitive behaviour, monopoly power |                                |
| 5.0 Analysis                                 | Assessment of China’s role and responsibility for social and environmental impacts of supply chain activity |                                |
|                                              | Assessment of key supply chain leverage points |                                |
|                                              | Linkage above with: 1. market context (actual and forecast); 2. policy framework |                                |

3 E.g., Voluntary standards, codes etc.
4 E.g., What percentage of China’s demand is driven by U.S. or EU demand?
References


