Uncovering the spatially distant feedback loops of global trade: A network and input-output approach☆

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HIGHLIGHTS

- Spatially distant feedbacks are identified for global trade and land-use.
- Data shows these feedback loops over a 10 year time span (2000−2010).
- Poorer countries exporting to wealthier ones increase their Land Trade Imbalance.
- Net exporters of land tend to form strong export ties with wealthier countries.

GRAPHICAL ABSTRACT
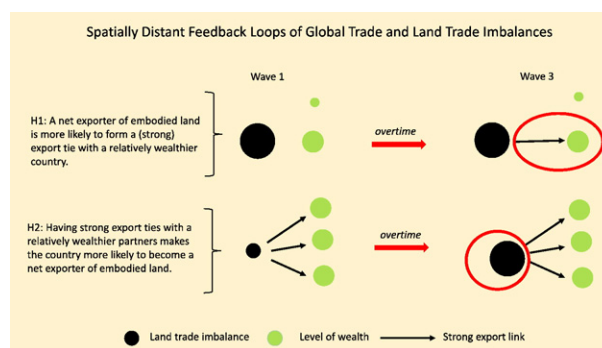
ABSTRACT

Land-use change is increasingly driven by global trade. The term "telecoupling" has been gaining ground as a means to describe how human actions in one part of the world can have spatially distant impacts on land and land-use in another. These interactions can, over time, create both direct and spatially distant feedback loops, in which human activity and land use mutually impact one another over great expanses. In this paper, we develop an analytical framework to clarify spatially distant feedbacks in the case of land use and global trade. We use an innovative mix of multi-regional input-output (MRIO) analysis and stochastic actor-oriented models (SAOMs) for analyzing the co-evolution of changes in trade network patterns with those of land use, as embodied in trade. Our results indicate that the formation of trade ties and changes in embodied land use mutually impact one another, and further, that these changes are linked to disparities in countries' wealth. Through identifying this feedback loop, our results support ongoing discussions about the unequal trade patterns between rich and poor countries that result in uneven distributions of negative environmental impacts. Finally, evidence for this feedback loop is present even when controlling for a number of underlying mechanisms, such as countries' land endowments, their geographical distance from one another, and a number of endogenous network tendencies.

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1. Introduction

Land-use change is increasingly caused by global drivers. The interdependencies between countries imply that human actions in one part of the world have impacts in another. In efforts to better understand the distant influence of human activities on land use, the concept of 'telecoupling' has been proposed as a new analytical perspective to address the increasing importance of distant connections and the growing complexity of the factors driving land use change. Telecoupling, first introduced by Liu et al. (2007), describes how natural and socioeconomic processes are linked within and across distant regions. In a telecoupled system, agents (e.g. individuals or corporations) in one location interact with aspects of the natural environment (in our case, various kinds of land) in either the same and/or different location. These interactions, over time, create both direct and spatially distant feedback loops in which both human activity and the natural environment mutually impact one another.

In the case of land, a growing body of research illustrates the ways in which land becomes embodied in international trade relations (EF and Meyfroidt, 2011; Lambin et al., 2001a, 2001b; Hubacek and Feng, 2016; Lambin et al. 2001; Schaffartzik et al., 2015; Seto et al., 2012; Weinzettel et al., 2013; Yu et al., 2013; Yu, 2014). Here, analysts demonstrate how land-intensive goods produced in one country get consumed in another, drawing attention to the spatially-distant relationships between consumption and production, and their associated environmental impacts. In doing so, this research often emphasizes that it is wealthy, developed countries that tend to be net importers of land-intensive goods, and hence, fulfilling their land requirements elsewhere, while poorer, less-developed countries are net exporters of such goods (Moran et al., 2013; Yu et al., 2013).

Classic and critical economic perspectives regarding global trade offer potential explanations for such environmental disparities between rich and poor countries. The 'comparative advantage' perspective (Porter, 1990; Ricardo, 1821) argues that economic agents in given countries strive to produce goods at lower costs in order to become competitive globally. Thus, in relation to embodied land, countries striving for a competitive advantage in the production of land-intensive goods can be assumed to tend towards becoming net exporters of land. Yet a more critical perspective would extend this argument by noting that, via a variety of historical events, wealthy, developed countries have accumulated a strategic position in the global economy, and are hence able to dictate the rules of global trade. Thus, these wealthier, developed countries extract undervalued, natural resources (such as land-intensive commodities) from poorer countries, and/or externalize resource-intensive activities to these more peripheral areas (Arrighi and Drangel, 1986; Chase-Dunn and Hall, 1993; Chase-Dunn, 1998; Jorgenson, 2006; Rice, 2007). Given this more critical perspective, it is not just that poorer countries may seek to develop a competitive advantage in certain kinds of exports, targeting wealthier markets in efforts to grow their economies (Jain, 2006; Pao and Tsai, 2010), but also, this process tends to place increased stress on poorer countries' environments, for example, through increased domestic land use (Moran et al., 2013; Yu et al., 2013; Yu, 2014), deforestation (Jorgenson, 2006), land and/or water grabs (Rullia et al., 2013), and emissions (Jorgenson, 2012, 2011; Kagawa et al., 2015; Moran et al., 2013; Prell and Feng, 2016).

Collectively, the above discussion on international trade and embodied land highlights how human activities and environmental impacts can span large spatial distances, where environmental impacts resulting from these activities become unevenly distributed among poor and rich countries. In addition, the above discussion suggests a feedback loop, in which land can both prompt new trade relationships and be impacted by these trade relations and/or their structural patterns. To make this more explicit, we note how past research indicates a positive relationship between being a net importer of land and wealth (Moran et al., 2013; Yu et al., 2013); research on global trade networks indicates that structural features of global trade and trade networks, e.g. level of centrality or position in the overall network, are good predictors of countries' wealth (Clark, 2010; Mahutga and Smith, 2011) and/or for environmental outcomes such as environmental pollution, either territorial or consumption based (Burns et al., 1997; Prell et al., 2014, 2015; Prell, 2016; Prell and Sun, 2015; Prew, 2010); and finally, research on trade tie formation has shown how features such as countries' level of wealth, proximity to other countries, and/or embodied carbon can prompt the formation of trade ties (Koskinen and Lomi, 2013; Prell and Feng, 2016), as well as even be considered to 'co-evolve' alongside environmental accounts such as carbon (Prell and Feng, 2016). Collectively, this research suggests that features of trade networks can predict changes in countries' environmental accounts (e.g. embodied carbon or land), and similarity, that the formation of these trade networks can be conditioned by these same environmental accounts, as well as other country characteristics, such as wealth.

A consistent trend across this research pertaining to trade networks is the focus on the structural patterns arising from the presence (or absence) of between-country trade ties (as opposed to the volume of capital flowing between countries, for example). In doing so, analysts tend to focus on the presence of strong trade ties, e.g. ties existing over and beyond a given cut-off value, in order to draw attention to the main structural features of the trade network (Kagawa et al., 2013, 2015). Doing so enables analysts to reduce the complexity of the network in question, allowing analysts to reveal the global structural features of the most important ties characterizing global trade, and in doing so, revealing important features implicit to ideas of economic globalization, namely, ideas of interconnectivity and/or regionalization (Kali and Reyes, 2010, 2007; Kim and Shin, 2002; Koskinen and Lomi, 2013; Prell and Feng, 2016; Reyes et al., 2010).

Given this past research, we propose two hypotheses, that combined and explore how trade tie patterns and Land Trade Imbalance(s) change in response to one another, forming a positive feedback loop:

H1. A net exporter of embodied land is more likely to form a strong export tie with a relatively wealthier country.

H2. Having a strong export tie with a relatively wealthier partner makes the country more likely to become a net exporter of embodied land.

In stating the two hypotheses above, we would like to clarify that a strong export tie refers to an export link that represents the upper 5th percentile of total trade between countries, and that a net exporter of embodied land refers to a country whose land-intensive exports exceeds its land-intensive imports. If support for H1 and H2 were found, we argue that such support would imply a positive, reinforcing feedback loop between displaced land-use and the formation (or maintenance) of strong trade ties, in which the embodied land of given countries are prompted by (but also drive) the presence and/or formation of strong export ties with wealthier countries. Thus, H1 conceptualizes the first half of the loop, testing how LTI levels drive trade tie formation. In contrast, H2 tests the second half of the loop, testing the impacts of trade ties on LTI levels.

Empirical confirmation of H1 and H2 helps clarify some of the complexities of global social ecological systems (Kissinger and Rees, 2010; Lenschow et al., 2016; Young et al., 2006), and demonstrate how consumers and producers are linked together in furthering environmental degradation through land use and land stress (Lenzen et al., 2007).