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The Water-Energy-Food Nexus in East Asia: A tele-connected value chain analysis using inter-regional input-output analysis

David J. White [a], Klaus Hubacek [a,e,*], Kuishuang Feng [a], Laixiang Sun [a,b,c], Bo Meng [d]

[a] Department of Geographical Sciences, University of Maryland, College Park, MD 20742, USA
[b] Department of Financial & Management Studies, School of Oriental and African Studies, University of London, London WC1H0XG, UK
[c] International Institute for Applied Systems Analysis, A-2361 Laxenburg, Austria
[d] Institute of Developing Economies, Japan External Trade Organization (IDE-JETRO), Chiba 2618545, Japan
[e] Department of Environmental Studies, Masaryk University, Brno, Czech Republic

HIGHLIGHTS

- Indicators are incorporated to examine the tele-connected sub-regional Water-Energy-Food Nexus.
- The impacts and tradeoffs between each subsystem is examined across multiple scale.
- Results reveal a mismatch between sub-regional resource availability and final consumption.

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ABSTRACT

Population and economic growth pose unique challenges in securing sufficient water, energy, and food to meet demand at the sub-national (regional), national, and supra-national level. An increasing share of this demand is met through trade and imports. The unprecedented rapid growth, extent, and complexity of global value chains (GVCs) since the 1980s have reshaped global trade. The GVCs – and new economic patterns of regionalization – affect the demands on water, energy, and food within countries and across global supply chains. East Asia is of particular interest due to the region's rapid economic growth, substantial population size, high interdependence of the region's economies, and varying degree of resource availability. While greater interdependence across the region has increased the efficiency of production and trade, these activities require the input of water-energy-food and generate disturbances in the environment. The transnational inter-regional input-output approach is utilized in a tele-connected Water-Energy-Food Nexus (WEFN) analysis of the East Asia GVC to assess competing demands for these resources and environmental outcomes.

This analysis demonstrates the hidden virtual flows of water, energy, and food embodied in intra-regional and transnational inter-regional trade. China's current national export oriented economic growth strategy in East Asia is not sustainable from the WEFN perspective. China is a net virtual exporter of nexus resources to Japan and South Korea. China's prioritization of economic growth and trade in low value added and pollution intensive sectors consumes a great amount of nexus resources within its territory to satisfy consumers' demands in Japan and South Korea. Japan's Kanto and Kinki regions and South Korea's Sudokwon region were the major beneficiaries while China bore the environmental burden associated with the production of exports. For example, net virtual exports from China's East region included over 1.2 billion m^3 of scarce water and 61.3 million metric (CO_2 equivalent) tons of greenhouse gases (i.e. CO_2, NH_4, and N_2O) and 2 million metric tons of SO_x emissions.

Trade is an important mechanism for overcoming resource bottlenecks, but, taking into account environmental linkages, regional specialization is not necessarily mutually beneficial. This analysis demonstrates a mismatch between regional water-energy-food availability and final resource consumption and the lack of attention for environmental impacts in national economic growth strategies. Resource scarce countries like China must, therefore, incorporate trade-off decisions between pursuing national economic growth, incurring environmental degradation, and food security into strategic regional development policies.

* Corresponding author at: Department of Geographical Sciences, University of Maryland, College Park, MD 20742, USA.
E-mail address: Hubacek@umd.edu (K. Hubacek).

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1. Introduction

In today's globalized world, population increase and economic growth pose important challenges in securing sufficient water, energy, and food to meet demand at the sub-national (henceforth, regional), national, and supra-national level. East Asia is of particular interest due to the region's rapid economic growth, substantial population size, relatively recent regional economic structural transformation, and differing degree of resource availability and environmental pressures. The unprecedented rapid growth, extent, and complexity of global value chains GVCs) since the 1980s have reshaped global trade and consumption of these three closely linked resources within and between countries [1]. Policies for water, energy, and food – at the regional and national levels – have numerous interwoven challenges; including access to resources, environmental impacts, securing national priorities (e.g. economic growth), and national security. The inter-connectedness of the water, energy, and food subsystems has become ever more apparent as evidenced by the increasing application of the Water-Energy-Food Nexus (WEFN) approach to identify tradeoffs and the search for cross-sector efficiencies to these challenges not only within countries but across global supply chains. With substantial quantities of commodities and services being traded across economic and ecosystem boundaries, an integrated assessment quantifying the virtually traded resources (and linked environmental pressures) of all three subsystems is needed in order to better understand the complexity of the WEFN and to adopt a comprehensive management approach. Furthermore, solving the issues of limited resource availability and sustainability requires an understanding of the integrated structure of the supra-national, national, and regional – see Fig. 1 – economies in the context of the WEFN.

Over the past six decades, countries in the East Asia region have enjoyed some of the highest annual gross domestic product (GDP) growth rates in the world by pursuing independent export oriented trade policies; dominated by trade with the United States [2]. The People's Republic of China, Japan, and the Republic of Korea (South Korea) each demonstrated 8% to 10% GDP growth rates for sustained periods of time; each achieving industrialization, urbanization, electrification, and motorization in the short span of 20–30 years [3]. The 1997–98 Asian Financial Crisis forced the East Asian countries to realign economic strategies and foster inter-regional economic cooperation – in the form of cross-border investments, financial coordination, trade, and inter-regional production networks – in order to avoid falling behind the European Union (EU) and North America GVCs [4]. The three economies became increasingly integrated and restructured the intra-industrial division of production and services to build up a highly interdependent network. China's accession to the World Trade Organization in 2001 resulted in a tremendous economic and political shift in the region. By 2005, the East Asia GVC had become established centered on China at its core [5,6].

GVCs divide up the production of goods and services into linked stages of production distributed across international borders and economies. Instead of producing a product originating from a single factory, a product originates from a network of suppliers from multiple locations [5]. China, as the manufacturing hub in East Asia's production networks, has been the main driving force increasing the inter-regional economic interdependence and an engine of economic growth. Over 50% of China's export is composed of processing trade – i.e. raw materials, parts and components, technology and equipment, and economic services are exported from other East Asian economies to China for final processing and then exported to the U.S. and the EU. China's huge domestic market is also a source of export growth for neighboring countries for both manufactured products and primary commodities. Typically, this results in China possessing a substantial trade surplus with the U.S. and a considerable trade deficit with Japan and South Korea [7,8]. In 2005, China's exports to Japan and South Korea totaled, respectively, $109.8 billion and $31.8 billion while

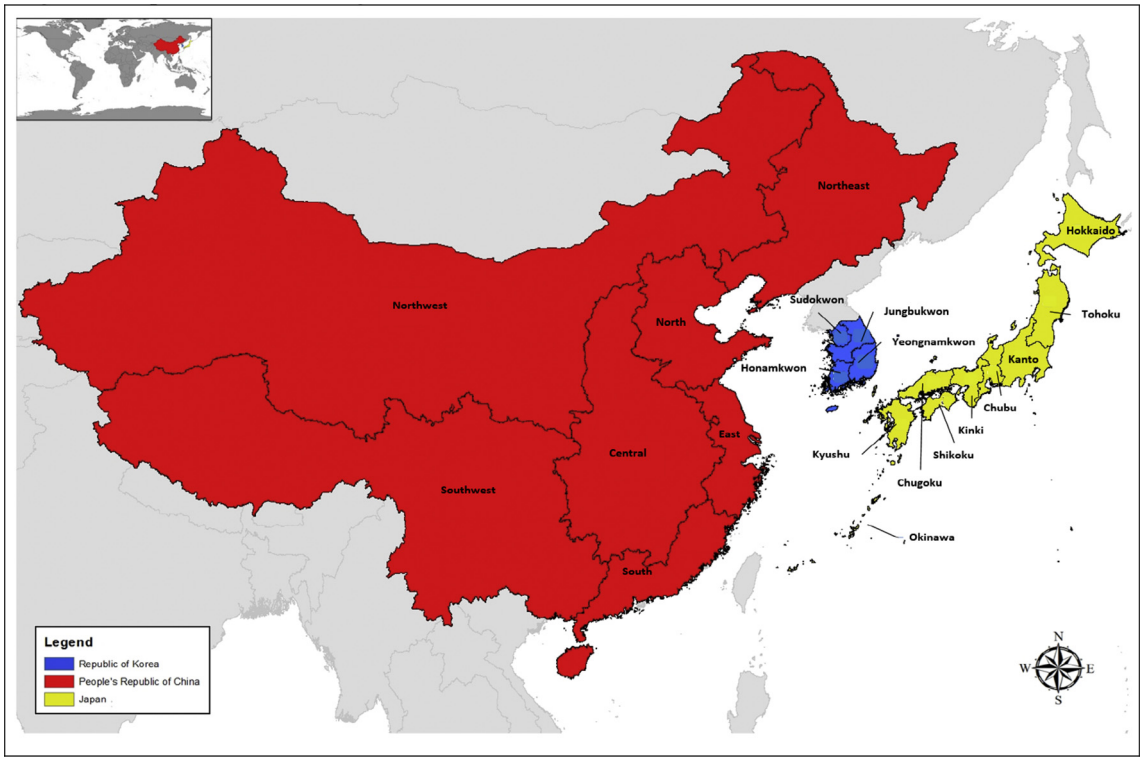

Fig. 1. Map of East Asia's regions.

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