



# Life cycle assessment of an energy-economy nexus: The case of Israel and South Korea

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## ABSTRACT

Israel and South Korea have both achieved rapid economic growth since their post-war establishment, and among the common challenges that the two countries have faced is a conspicuous lack of domestic oil supplies. Although this chronic energy scarcity has not impeded the economic trajectory of either country, it has influenced their industrial structures in strikingly different ways – with Korea nevertheless developing a vast energy-intensive manufacturing sector, while Israel has largely relied on its service sector to support a growing consumer society. While different in industrial structure, however, the two economies have been connected by intensive trade relations, meaning that energy is consumed in one country for the production of goods used in the other. In order to examine the economic and environmental implications of the two economies' structural divergence and bilateral trade relations, we use economic input-output analysis to track the life cycle (LC) energy consumption of passenger cars – a product which has significant environmental impact due to energy consumption in both its production and use stages – which were manufactured in Korea and exported to Israel during the period of 1997–2011. Our findings show that while most of the LC energy consumption of the vehicles occurs in Israel where the vehicle operation takes place, this does not mean that Israel's “avoided energy” by importing the Korean cars is insignificant. The embodied energy of vehicles traded in 2011 reached 3179 TJ, exceeding the amount of energy used by Israel's entire on-site building construction sector over the same period. If the Israeli economy had hypothetically developed its own auto manufacturing industry including secondary suppliers to meet domestic demand as well as exports – as was done in Korea – the energy consumption in those industries would be equivalent to about half of the current energy use by Israel's entire industrial sector.

## 1. Introduction

Israel and South Korea both achieved rapid economic growth in the decades following their establishment in 1948. Comparative studies have pointed out significant common factors influencing their rapid growth: both underwent modernization during colonial occupations; both had an autonomous state, bent on comprehensive economic interventions; local conglomerates were dominant, while multinational firms had a relatively weak sway; both received substantial capital inflows from outside sources in the form of aid and war reparations; and both faced formidable geopolitical complexity (Levi-Faur, 1998; Maman, 2002). However, the particular issue of energy resource scarcity has not been thoroughly investigated as a potential source of economic challenge in both of these countries. The persistent energy scarcity they have both faced due to a lack of domestic oil supplies is too critical to ignore, as such limitations can affect economic trajectory – particularly during periods of international crisis.

Despite their comparable economic successes, Israel and South Korea have diverged in their industrial structure. Israel's economy has taken on a more post-industrial structure than Korea's, focusing on its high-tech and service sectors. Korean manufacturing, on the contrary, has maintained a dominant position not only in the national economy but also in the global market. At the same time, while different in industrial structure, the two economies have been connected by active trade relations. Korean companies manufacture a variety of energy-consuming goods, many of which have been exported to Israel. Since they began bilateral trade in the mid-1990s, Israel's imports from Korea have steadily increased – rising from 328 million dollars in 1997 to 1.6 billion dollars in 2011 (in current value), a more than four-fold increase (UN Comtrade, 2015). During the same period Israel's overall import volume from the world increased by less than three-fold, so clearly the share of Korean goods has increased relative to overall Israeli imports since bilateral trade relations began.

One of the major goods whose trade was initiated in those years is

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motor vehicles, a typical energy-intensive commodity. In 1999–2005, passenger cars and personal phones were among the top end-use goods in terms of their relative share in the bilateral trade volume. While the share of personal phones has declined below 20% since 2006, the passenger car sector has maintained its large proportion of total trade value with only small fluctuations (OECD, 2014). Automobile production, as a typical modern manufacturing industry involving multiple inputs within domestic and/or international supply chains, is illustrative of the fact that Korea has embraced an economic trajectory relying on large-scale – and energy-intensive – industry, while Israel has not.

The economic and environmental implications of the two economies' structural divergence, and of the asymmetrical trade relations that have ensued between them, have never been systematically examined. Such an examination is relevant for environmental policy-making, because it seeks to uncover the indirect energy consumption (Li et al., 2014a; Chen et al., 2017), or energy “leakages” that occur between countries due to the production of goods in exporting countries and consumption of those goods in importing countries. According to Davis and Caldeira (2010), “consumption-based accounting” can demonstrate the potential for such international leakage, and promote the “sharing of responsibility for emissions among producers and consumers” – which in turn could “facilitate international agreement on global climate policy that is now hindered by concerns over the regional and historical inequity of emissions.”

With these objectives in mind, the current study was designed to implement two kinds of assessments – one qualitative and one quantitative. The first reviews the historical economic development of the two countries, in order to scrutinize the ways in which they have dealt with their energy resource constraints and to analyze the causes in a comparative manner. Based on the findings of this historical assessment, we then analyze the economic and environmental implications of the two economies' structural divergence through a quantitative assessment, or consumption-based accounting, of the bilateral trade relationship that has emerged from their disparate industrial structures. We have chosen a typical energy-intensive export product that is manufactured in Korea and used in Israel as the subject for a life cycle assessment (LCA). In this case study, we track the energy consumption of passenger cars manufactured in Korea and used in Israel, over the life cycle (LC) of the imported product. We assess the LC energy use of vehicles traded from 1997 to 2011, a period in which both countries were already considered high-income economies. External shocks during this period, like the 1997 Asian crisis and the 2008 global crisis, are considered in the interplay of the two open, market economies.”

## 2. Historical review

Here we review the economic trajectories of Israel and South Korea, and investigate their significant commonalities and critical differences. Factors which have affected their industrial structure and energy utilization are considered, particularly energy resource scarcity – which is investigated as a critical economic challenge which both countries have had to address during times of crisis.

### 2.1. Economic trajectories of Israel and South Korea

The history of Israeli economic development reflects both the distinct elements of its own situation and the changing conditions of the global economy, as Israel's economy has always been relatively small and highly dependent on resource inflows. The economy was decisively influenced by a dominant labor movement, recurrent waves of immigration, large capital inflows, ongoing geopolitical conflict, and a stark separation between societal sectors (Ben-Porath, 1986). The pre-state Jewish economy enjoyed high growth for most of the twenty five year period leading to statehood, under the British Mandate. Building on this success, the Jewish state's emergence opened a new era for the

economy, after initial difficulties caused by the 1948 War and unprecedented mass immigration. It enjoyed a golden age for more than two decades despite its near-constant state of war. During this time the economy was dominated by a highly interventionist governmental regime, and with its strong and ideologically-motivated labor movement, had a relatively high wage scale for workers in the county's main sectors (Ben-Porath, 1986). In 1973, however, the economy began a decade-long downturn followed by devastating triple-digit inflation in the first half of the 1980s. Along with the 1973 war, energy crisis, and international economic slowdown, significant internal impediments arose from the very features of the Israeli political economy: some major actors, such as the big conglomerates, became unsatisfied with state intervention and contributed to the shift towards neoliberalism (Ben-Porath, 1986; Maman and Rosenhek, 2011). The neoliberal transformation since the 1985 Economic Stabilization Plan turned the Israeli economy into a more market-oriented economy, open to globalization (Rivlin, 2011). The emergence of a successful high-tech industry in the last two decades, capitalizing on the country's highly-educated work force and access to global investment, has contributed to Israel's image as an economic success story.

The Korean economy has also become a success story, based on its rapid growth and transformation from an underdeveloped economy to a highly-developed one. In the 1950s and 1960s, the labor force began a massive move from agriculture to industry. The ensuing labor surplus allowed an almost completely elastic labor supply for local manufacturing (Ahn, 1994; Heo, 2012). Another significant quality in the Korean labor force, besides its low cost, was a much higher level of human development than reflected by income levels, as early as 1960. Meanwhile, the government was struggling to spur economic growth. This effort may be characterized by a developmental state perspective (Woo-Cumings, 1999), which emphasizes the distinct political and bureaucratic features of interventionist states as fundamental to the economic growth of East Asian countries. Along with the interventionist state acting as “the planner”, the unique political economy generated large, diversified business conglomerates (*chaebols*), which became core actors in industrial transformation and growth (Amsden, 1989; Evans, 1995; Wade, 1990; Woo-Cumings, 1999). Low labor costs and government intervention came at the expense of social priorities, especially in the realm of labor relations and rights – and in fact Korea has endured social unrest since the 1980s, due to embedded inequality, injustice, and a relative lack of democracy. According to Minns (2001), the economic miracle faced ‘great pressure’ in the 1980s and the developmental state ‘retreated’ from its strong interventionist policies. Thus while the economy prospered, demand rose for economic equality, labor rights, and democracy – but Korean labor compensation was again negatively affected by the 1997 Asian crisis. Whereas Korea's exports initially decreased after the 1997 Asian crisis, comparative data (US BLS, 2013) shows a lowering of wages due to the crisis that may have brought price advantages to Korean exports in the following years. On the whole, the 1997 Asian crisis changed the parameters of Korean economics in the long term, reducing the state's intervention in the economy and undermining the dominance of local conglomerates. The Korean developmental state lost its initiative, shifting to the mainstream neoliberalism of the global political economy since the late 1990s (Koh, 2010).

Comparing the two economies' growth and development, both governments played crucial roles through their comprehensive economic interventions. The way the state intervened, however, differed, particularly in the formation and transformation of their industrial structure. In Israeli manufacturing, one of the prominent national-level economic interventions occurred in the late 1950s when the state interfered with the textile industry to achieve the state's developmental goal (Levi-Faur, 1995). In the following decades, the state not only subsidized manufacturing plants, but also restricted the import of goods which were produced domestically (Aharoni, 1991), but did not really deal with the whole-sale structural changes of national industry as the

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