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How crude oil prices shape the global division of labor

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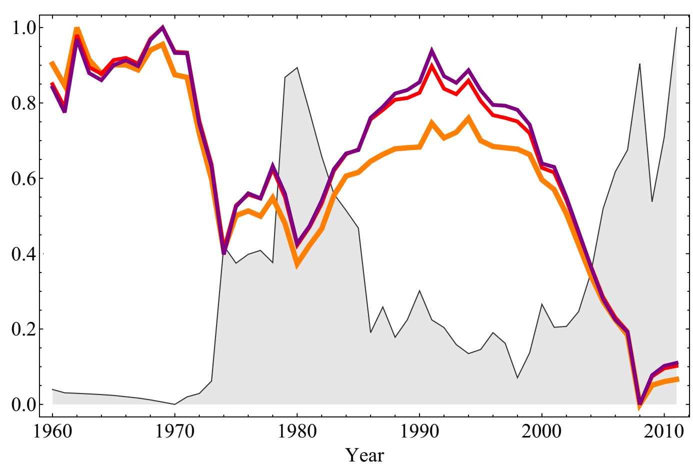
HIGHLIGHTS

- A network analysis of trade investigates the global value chains in the long run.
- The share of cyclic value shows a correlation with oil price of 85%.
- The null model proves that this is not explained by first order properties of network.
- Results show the link between crude oil price and the international division of labor.
- Transport costs had an underestimated impact on the structure of production globally.

GRAPHICAL ABSTRACT



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ABSTRACT

Our work sheds new light on the role of oil prices in shaping the world economy by investigating flows of goods and services through global value chains between 1960 and 2011, by means of Markov Chain and network analysis. We show that over that time period the international division of labor and trade patterns are tightly linked to the price of oil. We observe a remarkably high negative correlation (−0.85) between the oil price and the share of cyclical value, i.e. the share of value embodied in raw materials and intermediate products that are conserved across direct and indirect relationships. We demonstrate that this correlation does not depend on the balance of payments nor on the nominal value of trade or trade agreements; it is instead linked to the way Global Value Chains (GVCs) shape global trade. The cycling indexes show two majors structural breaks in terms of distance and length of GVCs, hinting at two phases of the recent globalization dynamics, sustained by two major transport modes. Our study suggests that transport played an important structural role in shaping GVCs, unveiling the deep, long-term impact of energy costs on the structure and connectivity of the global economy. In more theoretical term, our results indicate that the production structure could be approached as an energy system, forged by the efficiency in the transport sector. Understanding the role of oil in a globalized economy is of paramount importance for decoupling of economic growth from energy growth and transitioning toward a de-carbonized economy.

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1. Introduction

In the aftermath of the oil crisis of the early 1970s, the relationship between oil prices and economic growth became a focal point of the scientific discourse and public debate. In 1983, James Hamilton published an influential article showing that an oil price increase had preceded all but one recession in the United States since the end of World II [1]. Since then, a large number of empirical studies have looked into the connection between oil prices and real economic growth and frequently found a significant negative correlation [2,3]. The importance of this link between oil price and economic growth was less clear after the second oil shock [4–7]. Recent studies, with more refined statistical tools and price specifications, have restored the link between the oil price and economic growth [8–12]. There is now a general consensus that this connection did not cease but has become more complex in terms of direction (anticyclical and procyclical), typology of shocks (demand or supply) and lag patterns [4,9,11,13,14]. This line of research tried to explain this tight relationship, given that the cost of energy is only a small part of GDP [13] but satisfactory explanations have remained elusive [2,4,13,15]. Interestingly, this research exploring the link between the oil price and economic indicators seems to have entirely ignored the transport sector, which is heavily reliant on refined crude oil products, and its role in shaping the global division of labor. In the post-war period, world trade grew at a faster pace than world GDP [16]. According to recent studies on globalization, the remarkably high rate was propelled by a dramatic decline in international transport costs [16–19]. Perhaps, the notion that trade grew amid globalization because of transport should not come as a surprise. What is more surprising, but is closely related or even a corollary, is the fact, that intermediate and capital goods, in the last decades, grew faster than final products and now account for the largest part of trade in OECD countries [20]. While, in the aftermath of World War II international trade mainly concerned final products, the second wave of globalization (since the late 1980s) extended to intermediate products and capital goods, and the integration of factor markets as another important effect [21]. This process led to the fragmentation of production internationally [22]. Disregarding the transport sector, most of the scholars focused their attention on other factors in order to explain the fragmentation of the global value chain, like the pursuit of cheap labor or more favorable environmental legislation [21–23]. Amador and Cabral recently suggested that the strong increase of trade associated with the development of global value chains (GVCs) in the 1990s coincides with a period of low oil prices, although admitting that there is little empirical evidence linking these two factors [24]. These findings emphasizes the importance of assessing the impact of oil shocks upon an internationally integrated system rather than indivual countries. Furthermore, the new issues posed by climate change demand a deeper understanding of the nexus between energy consumption and the global economic structure. Our study addresses the connection between oil price and the global economy, by means of network theory and Markov chain theory, with the aim of understanding how the GVCs expanded and shrank following price changes in crude oil, between 1960 and 2011. Departing from a recent stream of research that investigated the structure of production with models and metrics based on Markov chain theory, on a disaggregated level (single sector or product) and limited time scale, [25–27], we analyzed the cycle of value on a global scale, at an aggregate level and employing a long time perspective. In contrast to previous analyses focusing on the oil-economy nexus that progressed by refining price specifications and statistical methods, we observed the correlation of the economy with the crude oil price (Brent), but we changed the macro-economic variables under investigation. We first applied network theory to trade imbalances and bilateral trade to understand how these two global measures of trade are linked to the oil price. These two quantities are thereby used to introduce the cycling index that builds on Markov chain analysis to assess the amount of value that is conserved across direct and indirect relationships in trade. With this measure, we looked at the share of cyclical value (the share of value that returns to the starting point), along different paths in the world trade network.

2. Analysis and results

2.1. Balance of trade per country: trade (im)balance

The balance of trade is the difference in value of national exports and imports and defines the status of *surplus* or *deficit* of the commercial balance, permanent or temporary, for every country (see methods). Many have viewed the existence of large current account imbalances as a possible cause of the financial crisis [28,29]. There is growing evidence that current account (im)balances are correlated to oil prices worldwide [29]. The reason for this correlation lies in the burden placed on imports (or exports, for oil exporting countries) by energy commodities, but also in monetary policies aimed at regulating inflation (which is correlated to oil price) [29]. The analysis has been performed on a yearly basis between 1960 and 2011, on aggregate trade flows (total import/export for every country), in nominal values (all measures are normalized to world GDP), of all the reporting countries in the world. Data are taken from Gleditsch's [30] and BACI datasets [31]. The fluctuation in the balance of trade and the variation of the adjusted crude oil price are moderately, yet statistically significantly, negatively correlated: the linear correlation coefficient is -0.32 (see Table 1). It is noteworthy that in a network where flows tend to be balanced at every vertex, the matrix tends to be symmetrical (which means that entries in the upper triangular part of the matrix mirror those in the lower) [32]. In other words, symmetric weights (flows) between every pair of vertices is statistically the simplest way to balance ingoing and outgoing flows at every vertex. A local symmetry (exports equals imports) tends to produce a global symmetry (export from i to j equal export from j to i). We thus expect that the balance of bilateral trade in the world trade web (WTW) to be negatively correlated to oil prices because we observe a negative correlation of the balance of trade locally. It should be noted though, that this is just a statistical relationship, obtained by imposing the local balance as a constraint in the null model [32].

2.2. Balance of bilateral trade: trade reciprocity

A global measure for evaluating the balance of trade between every pair of countries is the weighted reciprocity [32]. Reciprocity is a first-order property, meaning that it concerns the direct relationship of nodes with the nearest topological neighbors (one link-length). Reciprocity has proven to be an helpful measure in understanding the effects of the structure on dynamic processes, explaining patterns of growth in out-of-equilibrium networks [33,34], and starting to evaluate higher order properties [35–39]. The reciprocity for weighted networks, for every year $t, r_w(t)$, is defined as follows:

$$r^w(t) = \frac{\sum_i \sum_j \min[w_{ij}(t), w_{ji}(t)]}{\sum_i \sum_j w_{ij}(t)} \quad (1)$$

where $w_{ij}(t)$ is the trade from country i to country j during the year t (the subscript t will be omitted for simplicity for the remaining). If all flows are perfectly reciprocated/balanced then $r^w = 1$. If they are