

The Atlas of Economic Complexity: A Review

This discussion paper provides an exploration of the methodology used by Hausmann et al.'s (2014) Atlas of Economic Complexity. The Atlas provides a novel alternative to mainstream theories of economic growth and international trade. At the heart of the approach is an attempt to quantify the productive knowledge of a nation, which is inferred using a network-based approach to economic analysis. The authors argue that nations which possess greater productive knowledge, represented in a measure termed Economic Complexity, will produce more products and more complex products as part of their export baskets. This represents a significant departure when compared to earlier theories which suggest that more highly developed countries will produce more specialised goods. This discussion paper proceeds as follows: first, an overview of the Atlas' methodology is provided; then commentary will turn to the strengths and weaknesses of this approach.

Keywords: capabilities, Complexity Economics, economic development, international trade, Network Analysis, Product Space

Introduction

This discussion paper provides an exploration of the methodology used by Hausmann et al.'s (2011, 2014) Atlas of Economic Complexity. At the heart of the Atlas is an attempt to quantify the productive knowledge of a nation, which is inferred using a network-based approach to economic analysis. The authors argue that nations which possess greater productive knowledge, represented in a measure termed Economic Complexity, will produce more products and more complex products as part of their export baskets. Through their network-based approach, the authors provide a novel alternative to mainstream theories of economic growth and international trade. Their analysis significantly challenges earlier Ricardian and Heckscher-Ohlin trade theories which predict that the most developed economic will produce only a few products with a high degree of specialization (Heckscher & Ohlin, 1991; Ruffin, 1988). Instead, the Atlas finds that countries will produce the products for which they have the requisite capabilities and thus acts as a superior predictor of a nation's growth prospects and production structures (Hidalgo & Hausmann, 2009; Zaccaria et al., 2016). This discussion paper proceeds as follows: first, an overview of the Atlas' methodology is provided; then commentary will turn to the strengths and weaknesses of this approach.

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The Concept of Capabilities

Hausmann et al. (2014) explain the trade and production structures of economies as comprising of latent capabilities which are combined to form products. Economies are viewed as collections of heterogeneous latent capabilities that reflect the “modularised chunks of embedded knowledge” (Hausmann et al., 2014, p.16) or the “non-tradable inputs” (Hausmann & Hidalgo, 2011, p.3) required to make different products. This reflects a deep division of labour and emphasises the importance of tacit knowledge, which can be modularised at the level of individuals, firms, networks of firms, or inherent in the social, cultural and technological structures of a nation (Dosi et al., 1990; Hausmann et al., 2014; Zaccaria et al., 2016). The complexity of a product is a function of the competencies it requires, while the Economic Complexity of a nation reflects the number of locally-available competencies and determines the number and sophistication of products that can be produced (Felipe et al., 2012).

Capabilities are not defined a priori, but are inferred for a given country based on their trade proximity links and export composition, captured in this country-product network (Felipe et al., 2012). The authors model this by employing a bipartite network (the country-product matrix) that connects countries to the products they export, which itself results from a tripartite network that connects countries to their capability endowments (the country-capability matrix) and products to their required capabilities (the product-capability matrix) (Hidalgo & Hausmann, 2009; Hausmann & Hidalgo, 2011). This network is defined by the negative relationship between the diversity and ubiquity of an economy’s exports, and the non-normal distributions of product ubiquity, country diversity, and product co-export (Hausmann & Hidalgo, 2011; Hausmann et al., 2007). These relationships are captured by measures of diversity - the number of products in a nation’s export basket, and ubiquity - how many nations produce a specific product (Hausmann et al., 2014). Competencies are argued to be positively related to diversity and inversely related to ubiquity, hence reflecting the importance of agglomeration, and internal economies of scale and scope in explaining production structures (Bain, 1954; Glaeser et al., 1991; Marshall, 1920; Teece, 1980). This means that richer (or more complex) nations will have more competencies and thus be able to make more products requiring more competencies - i.e. these nations will be more diversified and less ubiquitous (Hausmann & Hidalgo, 2011; Hausmann et al., 2014).

The Product Space: Heart of the Network

The product space is used to graphically illustrate the collection of all trade proximity links, defined as all pairs of products with a probability of being co-exported (Hausmann et al., 2014; Hidalgo et al., 2007). Based on the tripartite network observed, the product space implies that trade proximate products share similar underlying knowledge and capability requirements (Hausmann et al., 2014). Given this, the product space illustrates a nation’s current productive knowledge and capabilities, and product opportunities that lie nearby (Hausmann et al., 2014). The product space is highly heterogeneous, and characterised by a core and periphery structure with densely connected product communities and a

sparse periphery (Hidalgo et al., 2007; Hausmann et al., 2014). The products located in these core communities – such as metals, machinery, and chemicals - exhibit long ladders and are highly sophisticated, sharing a large number of common underlying capabilities with other products (Felipe et al., 2012; Grossman & Helpman, 1991; Khandelwal, 2010). By contrast, the periphery comprises less sophisticated products – including agriculture and forest products, raw materials, and petroleum – they require fewer capabilities and the capabilities lack interconnectedness with other products (Felipe et al., 2012). This heterogeneous nature of the product space has been used to explain the differential levels of economic development across nations and the lack of convergence to a standard world income (Hidalgo & Hausmann, 2009). Richer countries are represented in the core with diverse and less ubiquitous production structures, while poorer nations are located in the periphery with less diverse and more ubiquitous production structures (Hausmann et al., 2014).

Hausmann et al. (2014) also use the product space to explain the process by which capabilities are generated, and thereby to highlight the path-dependent process of economic development. Economic development is a process that requires the acquisition of more complex sets of capabilities in order for a country to spin-off to new products that are more sophisticated and more productive than those in their existing export basket (Felipe et al., 2012). It is argued that a country is only able to diversify by developing new capabilities that are proximate to their existing capabilities and products, thus placing those countries already established in the core of the product space on a path-dependency to greater diversification and growth (Hidalgo et al., 2007; Hausmann & Hidalgo, 2011; Kali et al., 2013). By contrast, poor countries are typically located in the periphery and the lack of common capabilities, and product proximities, acts as an impediment to structural change and the development of new capabilities (Hidalgo et al., 2007). This gives rise to a quiescence trap, whereby countries with many (few) capabilities will face high (low) incentives to develop additional capabilities (Hausmann & Hidalgo, 2011). Subsequently, Hausmann et al. (2014) argue that a few rich countries will control the most advanced capabilities and products, while poorer countries will limit themselves to the less sophisticated product groups which require less capabilities (Saviotti & Frenken, 2008). Overall, the authors find a non-linear relationship between competencies and products which is dominated by increasing returns in terms of diversification to the accumulation of competencies (Hausmann & Hidalgo, 2011).

Strengths

Hausmann et al.'s (2014) measure of Economic Complexity (the ECI) successfully captures the latent value of an economy's underlying knowledge and capabilities used in production, highlighting that capabilities are pivotal in driving future growth and trade opportunities. Empirical evidence provided suggests that the ECI accounts for a large proportion of the cross-country differences in income per capita and economic growth, and acts as a superior predictor of economic growth when compared with alternative measures of institutional quality and governance, human capital, and competitiveness (Hausmann et al., 2014; Lee & Barro, 2010).

This analysis provides a country-level extension to the literature on firm strategy, which argues that sustainable competitive advantage is contingent on companies developing dynamic capabilities, and furthers the insights provided by endogenous theories of economic growth (Dinopoulos & Sener, 2007; Grossman & Helpman, 1991; Wu et al., 2016). The use of disaggregated trade data enables a detailed bottom-up, evolutionary analysis of a country's underlying production and export structures, based on product-specific capabilities (Beinhocker, 2006, 2011; Pietronero et al., 2013). Significantly, this level of disaggregation isolates those sophisticated product communities that form part of the interconnected core of the product space, from less complex products which are located in the periphery (Felipe et al., 2012; Fortunato et al., 2015).

This offers important policy implications by demonstrating areas where economic development efforts should be most targeted, i.e. which capabilities will lend themselves to yield the greatest gains in terms of production diversity and growth, and which capabilities are possible for a nation's development path (Felipe et al., 2012; Hausmann & Klinger, 2006; Hausmann et al., 2014). By focusing efforts for structural reform on more complex products, countries can benefit from a rapid unconditional convergence in product unit values across countries and thereby jump to a high-growth path (Aghion & Howitt, 1990; Hidalgo et al., 2007; Romer, 1990).

In addition, Hausmann et al.'s (2014) analysis strongly challenges traditional Ricardian and Heckscher-Ohlin trade theories which predict that the most developed economies will produce only a few products with a high degree of specialisation, i.e. that the country-product matrix will be block diagonal (Heckscher & Ohlin, 1991; Ruffin, 1988). The country-product matrix is instead found to be triangular, showing that countries will produce the products for which they have the requisite capabilities (Hidalgo & Hausmann, 2009; Zaccaria et al., 2016). This provides new insights into the predictive structure of the country-product network, and the inverse relationship between the diversity and ubiquity of production (Hausmann & Hidalgo, 2011).

Weaknesses

The data employed by Hausmann et al. (2014) has several limitations when it comes to measuring a nation's aggregate economic complexity. Specifically, Hausmann et al.'s (2014) analysis uses trade data as opposed to production data, and it may therefore underestimate the economic complexity of nations with a highly developed domestic or non-tradable sector (Inoua, 2016). For example, this methodology will likely underestimate the level of complexity for countries which are heavily reliant on non-tradables including construction, finance and real estate, or public services. Additionally, the exclusion of services from the authors' measure of economic complexity is likely to understate the complexity of service-based economies (Stojkoski et al., 2016). Stojkoski et al. (2016) find that complexity indices for services are, on average, higher than those for goods and argue that the diversification and sophistication of service exports can provide an additional growth path for economies. This is particularly relevant in the

Australian case, where services including education and tourism are accounting for an increasing share of economic activity and growth prospects (Kent, 2015).

The product space analysis used by Hausmann et al. (2014) also suffers from methodological limitations. Namely, it assumes that factors of production are constrained within national borders and that goods are produced entirely within a given economy (Scholkopf et al., 1997; Colombage, 2016). This overlooks the advent of the global supply chain, in which there is a growing importance of production sharing and an increasing prevalence of vertical integration across national borders (Coe et al., 2004; Hanson et al., 2005; Orefice & Rocha, 2014). This means that productive capabilities used by countries specialising in intermediate goods in the global value chain may not be directly considered (Hausmann et al., 2014).

Finally, the endogenous path-dependent nature of economic growth assumed as countries move through the product space to more complex export baskets does not account for asymmetric or idiosyncratic shocks (Fidrmuc, 2004; Toya & Skidmore, 2007). However, events including natural and man-made disasters or technological breakthrough may result in a sudden jump of a nation's trajectory from a high-growth to a low-growth path, or vice-versa (Palmer & Richards, 1999).

Conclusion

Hausmann et al.'s (2011, 2014) Atlas of Economic Complexity provides a useful extension to the theory on economic growth and development, and provides a greater insight into the productive structures of nations. Through their network-based approach, Hausmann et al. (2011, 2014) elucidate the importance of tacit knowledge and capabilities, captured by a measure termed Economic Complexity, in determining a nation's production structures. Fundamentally, the authors highlight that countries will produce the products for which they have the requisite capabilities. Thus, the Atlas expands on earlier theories of trade and growth and thus provides a superior predictor of economic growth and a deeper understanding of the path-dependent nature of economic development. Whilst these are definite strengths of Hausmann et al.'s (2011, 2014) analysis, their approach also suffers a number of limitations. Namely, the authors fail to account for the services sector of the economy, goods are assumed to be produced entirely within national borders, and potential asymmetric shocks to development are not captured by their model.

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