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Abstract: The capability framework in evolutionary economic geography views regional economic development as a process of related diversification through the acquisition of capabilities that render a regional economy more complex. Using this framework, we synthesize seven theoretical notions that hitherto remained rather disconnected: relatedness, complementarity, variety, complexity, diversification, agents of structural change, and related variety. We formulate a constructive critique of the capability framework, relaxing the overly restrictive assumption that the presence of capabilities in a region is both necessary and sufficient for complex products to be produced in a region. Instead, we argue that the complexity of a regional economy depends primarily on the institutions that support firms to coordinate production in complex value chains within and across regions. The augmented framework allows for closer integration of evolutionary and relational approaches in economic geography, providing new links between the literatures on clusters, innovation systems and global production networks.

Keywords: diversification, relatedness, complexity, institution, value chain

JEL-codes: B52 – O1 – O43 – R1

Introduction

Regional economic development is a central topic across multiple fields, including economic geography, economic history, development economics and the economics of growth.

Traditionally, the question of regional economic development has been approached from a macro-level perspective, understanding the size and growth of an economy from aggregate inputs, from investments in R&D and education, from the quality of institutions and from knowledge spillovers (Rodríguez-Pose and Crescenzi, 2008). With the advent of more fine-grained databases in the 2000s, empirical attention shifted from aggregate analysis of development to the process of diversification into specific products and how such diversification affects economic development across regions (Neffke et al., 2011; Boschma et al., 2013; Essletzbichler, 2015; Guo and He, 2017).

The turn from the aggregate level to the product level led to an alternative understanding of regional development as a path dependent process of ‘related diversification’, where the current portfolio of an economy structures the future opportunities for diversifying into new products. In this view, development is understood as an evolutionary process in which economies gradually move into related and more complex products as these develop over time (Balland et al., 2019; Davies and Maré, 2021; Mewes and Broekel, 2022; Rigby et al., 2022).

While our empirical understanding of economic development has greatly advanced, the theoretical understanding of the mechanisms of economic development remains somewhat elusive (MacKinnon et al., 2009; Henning, 2019). Below, we present one such theoretical framework which explicitly views development as an evolutionary process through continuous recombination of capabilities into products (Hausmann and Hidalgo, 2011; Inoua, 2016, 2023; Van Dam and Frenken, 2022). In a way, this theory harnesses the classic notion of the production function, but regards it as a ‘recipe book’ containing the explicit mapping of capabilities onto products (Dosi and Grazzi, 2010; Fink et al., 2017). By acquiring new capabilities, an economy can combine an increasing set of capabilities into more complex products.

Using the theoretical framework on capabilities and economic development, we synthesize a number of theoretical notions in evolutionary thinking about regional economic development

that have hitherto remained rather disconnected: the difference between (i) the relatedness of products and (ii) the complementarity of capabilities (Neffke, 2019), (iii) the relationship between (iii) variety and (iv) complexity of an economy (Inoua, 2016, 2023), (v) the principle of related diversification in economic development (Hidalgo et al., 2018), (vi) the agents of structural change (Neffke et al., 2018), and (vii) related variety as cause or effect of economic development (Frenken et al., 2007).

Below, we show how the capability framework synthesizes all these concepts in a single theoretical scheme. While powerful, the framework also suffers from strict assumptions about capabilities. We augment the capability framework of economic development by relaxing the assumption that the regional presence of capabilities is both necessary and sufficient for complex products to be produced in a region. We argue instead that the mere presence of regional capabilities is neither a necessary nor a sufficient condition for regional production to take place. On the one hand, if some capabilities required by a product are missing in a region, firms may still be able to integrate capabilities into products across geographical boundaries if effective institutions exist to govern inter-regional value chains. On the other hand, even if all capabilities associated with a product are present in a region, firms may still be unable to integrate them if supporting territorial institutions are lacking. Institutions thus constrain the maximum complexity of products that agents can handle. Hence, as we will argue, capability acquisition and institution-building should go hand in hand in the process of economic development.

The capability framework

Theorizing regional economic development as a continuous process of diversification, one can describe a regional economy as the portfolio of products (a term in which we include services in the remainder of this text) that is produced at any given moment in time. To be able to produce a particular portfolio, the collection of agents active in an economy requires particular capabilities associated with the products in the portfolio.

Evolutionary theorizing in economics often invokes the notion of organizational capabilities: intentional actions within an organization to produce specific outputs. Thus, originally, capabilities have been understood as a property of organizations (Dosi et al., 2000). The notion of organizational capability is distinct from the notion of organizational routines,

which represent repetitive and predictable behavioral patterns of organizations, and also from the notion of skills, which refer to individual capacities of employees working for an organization (Nelson and Winter, 1982; Henning, 2022).

In more recent work by Hausmann and others on the economic development of regions and countries (Hidalgo and Hausmann, 2009; Hausmann and Hidalgo, 2011; Neffke et al., 2018; O’Clery et al., 2021), capabilities are similarly understood as the set of inputs that are needed to produce a specific output. However, in this framework, capabilities are assumed to be non-rivalrous and – at least to some extent, non-excludable – among co-located firms in their use so that multiple local actors can leverage them in their production processes (Neffke et al., 2018). It is in this way that one can conceptualize capabilities as a property of a country or region drawing parallels to the Resource-Based View of the firm (Barney, 1991), according to which resources confer sustained competitive advantage only if they are “VRIN”: valuable, rare, imperfectly imitable and non-substitutable. However, to count as regional capabilities, such resources must be accessible to other firms inside the region, but not – or only imperfectly – to firms outside the region (Neffke et al., 2018; Henning, 2022). That is, they need to be locally, albeit not globally, non-rivalrous and non-excludable.¹ Examples of such regional capabilities are low cost bulk shipping provided by coastal access, engineering prowess embedded in a region’s capacity to train or attract skilled engineers and access to advanced know-how in specific technologies through local research labs and universities.

Our theoretical framework starts from the assumption that, at the granular level of individual products, capabilities are strictly complementary – akin to a Leontief production function – implying that missing one of the required capabilities makes it impossible to produce a product (Kremer, 1993). If one were to accept the (strong) assumption that a product is produced once all required capabilities are present in a region, then the set of capabilities present in a region determines the set of outputs in that region at every moment in time. In this case, a region will move up the development ladder each time its economy acquires a new capability, which renders new combinations of capabilities feasible that allow for the

¹ This notion of regional capabilities differs from an earlier notion of Maskell and Malmberg (1999) who understand regional capabilities as including human and physical resources as well as the specific institutional endowment in a region. Our notion is closer to the framework developed by Henning (2022) who distinguishes between firm resources, regional resources, and regional capabilities. However, different from Maskell and Malmberg (1999) and Henning (2022), and as we will elaborate below in our augmented framework and in a model (Figure 2), we distinguish between capabilities and institutions, where the quality of institutions is expressed as the maximum number of capabilities than can be recombined.

production of new products, expanding the economy's portfolio. As the total number of capabilities grows, new products will be more sophisticated, *viz.* more 'complex', than existing products because new products will combine, on average, more capabilities than existing products (Figure 1).

--- Figure 1 around here ---

More complex products have higher value added given that a more fine-grained division-of-labor underlies their production processes (be it organized within firms or between firms in value chains). Furthermore, it is reasonable to expect that workers involved in the production of more complex products earn higher wages.² Thus, the average complexity of products is closely related to the average income in an economy, meaning that the complexity of a regional economy can be understood as a measure of economic development (Hidalgo and Hausmann, 2009).

As an elementary evolutionary model³, one can view regional development as a process of capability acquisition, leading to diversification into new products of rising average complexity. The challenge of economic development can then be understood as a challenge of capability acquisition (Lall, 1992; Fagerberg et al., 2010), as the complexity of an economy can only grow through the addition of new capabilities (Hidalgo and Hausmann, 2009; Van Dam and Frenken, 2022).⁴ Using this framework, we can synthesize and further develop evolutionary theorizing in economic geography connecting some of the core concepts in recent scholarship including relatedness, complementarity, variety, complexity, related diversification, agents of structural change, and related variety.

Relatedness

² This assumes that workers have at least some bargaining power over how the benefits of this higher productivity are distributed between capital and labor. In fact, it is likely that workers' bargaining power rises with the complexity of production, given that disruptions of work processes become more costly with rising complexity.

³ The evolutionary nature of the model of capability acquisition lies in the growing number of capabilities leading to more complex products, where a set of capabilities corresponds to the genotype and a resulting product to the phenotype. Analogously, in biology, the process through which a genotype grows in terms of number of genes is known as genome growth giving rise to constructional selection (Altenberg, 1994).

⁴ This conclusion is also consistent with, and strengthened by, earlier evolutionary reasoning about the saturation of demand for any given product. As demand for any given product saturates, new products need to be introduced to restore demand and to employ the capabilities made redundant in the production of existing products (Saviotti and Pyka, 2004).

In the capability framework, relatedness between two products refers to the number of capabilities they have in common. By definition, two products can never be exactly the same as each product has a unique production function specifying a unique bundle of capabilities required to produce that product. Logically, then, the relatedness between two products ranges from having no capabilities in common at all (minimum) to having all capabilities in common except one (maximum). Developing new products involves recombining old and new capabilities into new configurations that have economic value. Since these new recombinations will consist of a new capability and capabilities that were already present, new products will be related to existing ones, giving rise to ‘the principle of relatedness’ (Hidalgo et al., 2018).

Complementarity

Given these two layers of capabilities that translate into products, one can distinguish between relatedness and complementarity (Farinha et al., 2019; Neffke, 2019). Just as two products can be more or less related depending on the number of capabilities they have in common, two capabilities can be more or less complementary depending on the number of products that require both capabilities. Capabilities co-occurring in many production processes have high complementarity, meaning that the value of the presence of one capability rises substantially in the presence of the other. Other capabilities may never, or only rarely, co-occur in production processes indicating low complementarity: the value of one capability is independent of the presence of the other.⁵

Variety

As a region develops over time through the acquisition of new capabilities, new products will enter its product portfolio. We can empirically assess regional economic development simply by counting the number of products it produces at a given moment in time. This count is

⁵ One critique of capabilities-based frameworks is that they do not account for the fact that some capabilities are more complex than others. The notion of complementarity provides an elegant way to account for such differences in complexity across capabilities by introducing *composite capabilities*. Composite capabilities consist of unitary capabilities of equal complexity that are highly or even perfectly complementary to one another to the extent that they can only be successfully employed if all components of the composite capability are present.

known as the ‘variety’ of an economy.⁶ Following our framework, because production functions prescribe how capabilities translate into products, the variety of products is a direct outcome of the presence of particular capabilities. Under certain assumptions, it can be shown that as the number of capabilities increases linearly over time, the variety of products increases exponentially, due to the rapidly increasing number of combinations of capabilities translating into feasible products (Inoua, 2016, 2023; Van Dam and Frenken, 2022).

Complexity

The ability of an economy to make a certain variety of products depends on the capabilities present in a region and the ways in which capabilities complement each other. The acquisition of a new capability does not only allow an economy to diversify, and therewith increase its variety of products, but also to ‘complexify’ by producing, on average, more sophisticated products. Combining more capabilities implies a more intricate production process leading to products that are arguably more sophisticated compared to combining only few capabilities. The sophistication, or ‘complexity’, of a product can then be expressed by the number of capabilities required to produce this product, and the complexity of an entire regional economy as the average complexity of products in the economy’s product portfolio. The average complexity of products produced in a regional economy can thus be understood as a measure of regional economic development.⁷

⁶ At any moment in time, an economy can be described by its variety in terms of the number of products it produces. In case one would have data to proxy the capabilities associated with each product (e.g., using data on professions, knowledge, technology, *et cetera*), one can further adjust the measurement of variety of an economy by the relatedness between products as measured by the number of capabilities that products have in common, as elaborated using Hill numbers by Van Dam (2020). Note that this measurement of variety, which takes into account relatedness, differs from how related variety has been measured in the past by Frenken et al. (2007), overcoming the known limitations of the entropy decomposition, which is based on a predefined hierarchical classification (Content and Frenken, 2016; Bathelt and Storper, 2023).

⁷ Under the assumption of randomly distributed complementarities, the average complexity of product will increase linearly with the number of capabilities while the variety of products will increase exponentially with the number of capabilities (Inoua, 2016, 2023; Van Dam and Frenken, 2022) (see also Figure 2). This assumes that not all combinations of capabilities are sensible and that the share of sensible combinations decreases exponentially with the number of capabilities that are attempted to be combined. Assuming that capabilities are acquired at a constant rate, the resulting linear increase in average complexity is consistent with a stable income growth path of economies. Without any knowledge of exact production functions that map capabilities onto products, however, the observable number of products of an economy (variety) is the best guess of the unobservable number of capabilities (complexity). That is why the complexity of an economy can be approximated by taking the logarithm of variety that an economy produces (or exports). Indeed, the logarithm of the count of products has been shown to correlate strongly with GDP per capita (Inoua, 2023). Moreover, Gomez-Lievano et al. (2017) provide theoretical foundations for why the diversity in output rises exponentially as the number of capabilities in a city increases. A different way to measure the capabilities of an economy can be derived from comparing economies and products. Simple products can be produced by many economies as the few capabilities that are required will tend to be present in many economies. By contrast, complex products

Related diversification

Diversification can be defined in the context of regional economic development as the process through which a regional economy expands the number of products it produces (Boschma, 2017). Reasoning from our framework, in which products can only be produced if all required capabilities are present, the process of diversification is essentially a process of capability acquisition. Each time a new capability is acquired by the collective of agents in an economy, the number of products produced will expand to the extent that the new capability is complementary to existing capabilities.

To illustrate how development can be described as a process of related diversification, consider the following thought-experiment that compares two extreme cases of capability acquisition: one in which the new capability has no complementarity at all with any existing capability, and one in which the new capability is fully complementary with all existing capabilities. In the first case, the acquisition of a new capability will lead at most to one new product with unit complexity (i.e., the product that uses only the newly acquired capability), and will hence not raise average complexity of products in the region. Because the new product does not have any capability in common with existing products, it is fully unrelated to the existing products in the region. In the second case, by contrast, all capabilities can be recombined with the new capability in any possible combination and of any complexity. Consequently, the newly acquired capability will set in motion an explosion of new products with the average complexity of a region increasing. And, because the new products added to the region's portfolio have many capabilities in common with the existing products, they will be highly related to pre-existing products. What these two cases show, is that – even if the acquisition of new capabilities were to be a random process – most of the new products that are added to an economy's portfolio will be highly related to the existing ones. This conclusion follows from the fact that the otherwise random acquisition of a more complementary capability will lead to many more, and more related, products than the random acquisition of a less complementary capability. This is a direct implication of the

can only be produced by few economies, having all the capabilities that are required to produce a complex product. Combining information on the variety of products an economy exports with the number of other economies exporting these products as well, lies at the basis of measures of economic complexity (Hidalgo and Hausmann, 2009; Tacchella et al., 2012).

relationship between relatedness and complementarity: the more complementary the new capability is, the more products can be produced, and the more these products will be related to existing ones. Thus, most instantiations of diversification will be related rather than unrelated. Empirically, one can assume this process not to be random *per se*, as agents are likely to seek new capabilities that are complementary to the capabilities already present as to create more diversification opportunities. This endogenous dynamic would thus further reinforce the relatedness in regional diversification processes.

The rate of economic development, expressed as the increase in the average complexity of products, depends on the rate at which capabilities are acquired and the extent to which these capabilities are complementary to existing capabilities. The more complementary new capabilities are, the more complex the new products will be. At the same time, the more complementary new capabilities are, the more related the new products will be. Thus, relatedness and complexity are two sides of the same coin in economic development: as the collective of agents acquires new capabilities and recombines these with existing capabilities, an economy develops by making more complex products that tend to be related to existing products. In sum: economic development can be understood as a process of related diversification through the acquisition of capabilities that render an economy more complex.

The framework of related diversification does not preclude that products may also disappear from a region's portfolio. Theoretically, the so-called 'hump' in economic development – the fact that, as economies develop over time, variety first increases and then decreases – has been integrated in the capability theory of related diversification (Van Dam and Frenken, 2022). This hump-shaped pattern in economic development can be understood from the fact that wages rise when an economy becomes more complex. In as far as these rising wages lead to rising local prices of nontraded goods and services – a well-known aspect of Dutch disease – they will put upward pressure on wages negotiated in other sectors and on minimum wages set by governments. As a result, low-complexity products become too expensive to produce given the high labor cost involved in highly complex regional economies compared to regions with lower complexity. Thus, progressively, products with low complexity exit the product portfolio of a region, further increasing the average complexity of the products that remain in a region's portfolio. Beside this, products can disappear with the advent of a new techno-economic paradigm as witnessed with the rise of ICTs (Freeman and Perez, 1988). Note that such creative-destruction dynamics do not only lead to a substitution of a range of

products, but may also affect the structure of complementarities between capabilities, and, as a result, the competitiveness of regions over a long period of time.

The evolutionary theory of related diversification resonates with the empirical ‘relatedness’ program in evolutionary economic geography that has developed in recent years along two lines. The first line of research was sparked by the seminal paper on related diversification at the country level by Hidalgo et al. (2007). Since then, empirical studies on regional diversification processes, using data on exports, production, employment, occupations, patents, and publications, found ample evidence that diversification is most often related (see, for a review, Hidalgo et al., 2018), although some scholars have raised doubts about the standard methodologies used to measure relatedness and have proposed alternatives (Coniglio et al., 2018; Van Dam et al., 2023). The second, more nascent line of research investigates the relation between related diversification, complexity and regional economic development. By now, several studies have shown that regional development is best served by the development of new complex technologies that build on local related capabilities (Balland et al., 2019; Davies and Maré, 2021; Mewes and Broekel, 2022; Rigby et al., 2022). However, again, some doubts have been expressed about the validity of the exact complexity metrics used (Tacchella et al, 2012; Mealy et al. 2019).

Agent of structural change

The capability framework views economic development as a process of acquiring ever more capabilities that allow for the production of ever more complex products, which, in turn, translates into higher income per capita. In this view, the ‘driving force’ in regional economic development is the acquisition of new and complementary capabilities, because regions can only produce more complex products if they acquire such capabilities.

Empirical studies in evolutionary economic geography distinguish between internal and external sources of capability acquisition (Zhu et al., 2017; Bahar and Rapoport, 2018; Neffke et al., 2018; Elekes et al., 2019; Balland and Boschma, 2021; Crescenzi et al., 2022; Diodato et al., 2022). Within a region, local firms, entrepreneurs, universities and public organizations may all develop new capabilities that support the production of new and more complex products. From outside a region, new capabilities may enter the region via migrants and multi-locational companies.

One can expect that local actors look more often for capabilities that are most complementary to locally existing capabilities and therefore mostly engage in related diversification. In contrast, non-local actors bring with them capabilities without much regard for the existing capabilities in an economy. These actors are therefore more likely to engage in unrelated diversification. Consequently, while local agents may spur economic development in the short run, non-local agents are important for introducing low-complementary capabilities, which may secure long-run development once the acquisition of highly complementary capabilities is exhausted (Saviotti and Frenken, 2008; Hidalgo, 2023). This line of thinking aligns well with the growing literature on regional path creation, in which agents actively engage in new capability formation, supported through linkages within and between regions, to support the development of new industries (Carvalho and Vale, 2018; Trippel et al., 2018; Hassink et al., 2019; MacKinnon et al., 2019).

Related variety

On a final note, the capability framework presented here also links to the concept of related variety (Frenken et al., 2007; Castaldi et al., 2015). The theoretical relationship between related variety and economic development originally put forward by Frenken et al. (2007) is however different from the framework proposed here. The former study reasoned from knowledge spillovers, formulating the expectation for: “knowledge spillovers within the region to occur primarily among related sectors, and only to a limited extent among unrelated sectors” (Frenken et al., 2007, p. 688). These knowledge spillovers generate new ideas for new products, which would then enter the economy and enhance employment growth. By contrast, in the framework presented above, the ultimate cause of economic development is the acquisition of new capabilities, with the rate of economic development depending on the speed at which capabilities are acquired and the extent to which these complement existing capabilities. Hence, related variety would not be a cause, among other causes, of economic development, but a logical outcome of the evolutionary process of development (Martin and Sunley, 2022; Bathelt and Storper, 2023).

While the original theory about related variety differs from the theory based on capability acquisition, knowledge spillovers play an important role in both. In the related-variety theory, knowledge spillovers are at the core of innovation *viz.* value creation. Because agents who

are active in different but related industries learn from one another, they are able to develop and introduce new products (Frenken et al., 2007). In the theory based on capabilities, diversification stems from the acquisition of a new capability. Such new capabilities, in turn, are often acquired through spillovers from other regional economies via interactions with neighboring regions (Bahar et al., 2014), migration (Bahar and Rapoport, 2018), knowledge networks (Balland and Boschma, 2021), and FDI (Crescenzi et al., 2022).

Augmenting the capability framework

Understanding regional economic development as a process of acquiring complementary capabilities to produce ever more, and more complex products, provides a coherent theoretical perspective that is consistent with a large body of empirical evidence in evolutionary economic geography. However, while coherent and supported by empirical evidence, the framework is also limited. In particular, it views regions as ‘containers’ of capabilities without explicitly accounting for the relational structures between firms operating in value chains within and across regions. In the remainder, we argue that the capability framework needs to be augmented analytically, paying explicit attention to the role of value chains that underlie the production of goods and services.

Relaxing the core assumption

The core assumption underlying the original formulation of the capability framework (Hidalgo and Hausmann, 2009; Hausmann and Hidalgo, 2011; Inoua, 2016, 2023; Van Dam and Frenken, 2022), holds that the regional presence of capabilities required to produce a particular output is both a *necessary* and a *sufficient* condition for a regional economy to produce that output. This is why, theoretically, the addition of a new capability will automatically, and without friction or delay, cause a region to produce more, and more complex, products. One can nuance, and augment, the capability framework of regional economic development by relaxing this assumption. Paraphrasing Boschma’s (2005) notion that geographical proximity is neither necessary nor sufficient for inter-firm collaboration, we argue that the co-location of capabilities in a region is neither a necessary nor a sufficient condition for the production of complex output.

The regional presence of capabilities is *not necessary* for production to take place, because firms can access capabilities residing in other regions by leveraging intermediate stages that take place in other regions that possess the requisite capabilities. Such inter-regional value chains underlie most complex products today. The trade and investment linkages of a region with other regions thus affect the complexity of the regional economy *viz.* the income per capita generated. By including inter-regional trade, outsourcing and investments, as well as corporate ownership ties into the capability framework, one can generalize the framework from its typical application to a closed economy to an open economy model.

What is more, the regional presence of capabilities may be *insufficient* for complex products to be produced. This becomes evident once we relax the strong assumption that all capabilities can be accessed by all firms in the region. In fact, firms often need to make complementary investments to utilize local capabilities. For instance, going back to our earlier examples, to employ the engineering skills embedded in a local labor force, firms will need to invest in relevant physical capital and organizational routines that allow these engineering skills to be put to use. Similarly, a coastal location can only be exploited by firms investing in maritime technologies, such as ships or marine pipelines. As a consequence, the capacity to leverage the regional variety in local capabilities will be distributed across different firms. Aggregating all local capabilities then requires coordination across firms. That is, mere co-location of firms does not guarantee that these firms are able to effectively integrate their capabilities and the capacity to utilize different types of local capabilities in intra-regional value chains. While co-location may certainly help to establish complex value chains by affording geographical and institutional proximity, such proximities are no guarantee that such value chains emerge within regions.

Relaxing the assumption that the regional presence of capabilities is both necessary and sufficient for outputs to be produced in a region puts value chains center stage. Rather than reasoning from a single region that has all capabilities required to produce an output, a generalized view on regional economic development holds that outputs are produced through value chains that connect intermediate outputs, each of which may build on its own unique capabilities (Henning, 2022). Note that, in principle, organizations other than firms can be part of such value chains (e.g., public actors, NGOs, universities) as the capability framework in itself is agnostic about the precise organizational carriers of capabilities that result in outputs. Moreover, by internalizing segments that require particularly high levels of

coordination, multi-locational firms are not just participants in, but also important orchestrators of, value chains (Dicken, 1986). In this sense, multi-locational firms can substitute or complement institutions by using internal organizational processes to facilitate the coordination of spatially distributed regional capabilities. This role of multilocal firms is particularly important for regions with a low quality of institutions.

Having introduced value chains into the capability framework, a next logical question is why (firms in) regions may differ in their ability to participate in complex value chains. Here, one can assume that, on average, more complex products will have longer value chains. Hence, the ability for a region to develop by producing ever more complex outputs depends on the ability of its firms to participate in complex value chains by coordinating the integration of distributed capabilities (Henning, 2022), be it as a producer of intermediate or final outputs, and their ability to extract surplus from the value added created in the value chain.

A consequence of the focus on value chains is that institutions acquire a crucial role in our capability framework of economic development. Institutions reduce transaction costs in value chains and collaboration costs in collective invention. In these ways, institutions support firms and other organizations in coordinating their productive and inventive activities in intra- and inter-regional value chains to increase the complexity of the output they produce. It is the increase in average complexity of an economy that translates into the production of higher value-added products and, as a result, rising incomes. The quality of regional institutions, and the national and supra-national institutions in which a region is embedded, are manifest in a region's ability to combine capabilities through both intra-regional and inter-regional value chains. In modelling terms, one could thus express the overall quality of institutions as the maximum complexity of outputs that a region is able to produce via intra- and inter-regional value chains.

The challenge for regional agents is that they must continuously develop and adjust institutions to support the integration of ever greater numbers of capabilities within and across regions. Note that the framework does not pre-specify what type of institutions would allow for higher product complexity. If anything, institution-building is a creative process that is both path-dependent shaped by the specific order in which capabilities are acquired over time and place-dependent given the political economy within and across regions (MacKinnon et al., 2019; Barca et al., 2012; Rodríguez-Pose, 2013).

A theoretical implication of our augmented capability framework states that long-term economic development is assured only if the institutions co-evolve with the expanding set of capabilities *within* and *outside* a region, so that agents are able to integrate more capabilities into more complex products. Would institutions no longer evolve to accommodate the production of increasingly complex products, the average complexity of products will no longer increase linearly with the number of capabilities. A model illustrating this argument is presented in Figure 2. This theoretical insight highlights the need to focus our research not just on mapping complex value chains *per se*, but also on the regional, national and supra-national institutions that support them. Data on such institutions can then be used to explain differences in the complexity of products produced across regions.

Theoretical connections

The augmented capability framework speaks to at least three bodies of literature that have remained rather disconnected from the capability framework in evolutionary economic geography, centering around the notions of clusters, innovation systems, and global production networks.

First, regarding *intra*-regional coordination in complex value chains, corporations have been understood as a nexus of relations with different actors holding different capabilities, including suppliers, clients, competitors, governments, professional organizations, financial organizations, labor unions, universities and schools. These organizations jointly support the production and invention of increasingly complex products. All these relations, in turn, are structured by institutions, as scrutinized in past research on clusters (Porter, 1998; Iammarino and McCann, 2006) and regional innovation systems (Braczyk et al., 1998; Coenen et al., 2017).

Second, coordination in innovation and production processes takes place in *inter*-regional value chains leading up to a final product. For multi-regional and multinational enterprises to orchestrate such delicate value chains, and appropriate surplus from the value added created, a range of supportive regional, national and supra-national institutions are needed, including trade regulations, insurance schemes and effective contract enforcement, to reduce transaction costs and investment uncertainties (Gereffi et al., 2005). In this respect, the notion

of value chains as linear transaction structures is limited. Instead, it is more useful to think of global production networks as encompassing a broader set of actors embedded in the institutions of the global economy (Coe et al., 2008; Yeung, 2021). This production-network perspective can be extended with an innovation-network view, where organizations benefit from transcending their regional and national innovation systems, by linking to key organizations across the globe to advance the technological frontier. In this context, the recent notion of global innovation systems highlights the role of global networks and institutions to support innovation in particular sectoral contexts (Binz and Truffer, 2017).

While studies on clusters and regional innovation systems focus on intra-regional relations and studies on global production networks and global innovation systems on inter-regional relations, the two topics can be further put into conversation (Humphrey and Schmitz, 2002). For example, in regions that host many firms operating in global value chains, one may think differently about the organization of a cluster or regional innovation system than in regions where firms operate mainly locally. This proposition bears similarity to the work on national innovation systems of small countries with open economies (Fagerberg et al., 2018). Reversely, looking at specific global production networks, one may ask how innovative activities distributed across multiple clusters and regional innovation systems can be aligned through global pipelines (Bathelt et al., 2004), including the role of technical standards and digital platforms herein.

Recent evolutionary theorizing addressed the interplay between regional and global development by focusing on functional upgrading (Boschma, 2022; Hernandez-Rodriguez et al., 2023; cf. Pahl and Timmer, 2019). In the past, evolutionary economic geography focused mainly on regional development as a process of diversification into new products, and much less on functional upgrading within products, for example, from transport to logistics, from sales to marketing, from production to R&D, *et cetera*. The insertion of regional firms in multiple value chains allows for a regional focus on the specific capabilities supporting particular functions. In this way, a region can sustain a large degree of product diversification while at the same time specializing in the capabilities associated with specific functions. This means that regional economic development need not be conceived of only in terms of diversification into more complex products, but also in terms of specialization in more complex functions, carried out in multiple global value chains simultaneously.

On a final note, the augmented capability framework resonates with a more recent theme in economic geography: geopolitics. Understanding regional development as depending not just on the capabilities present in a region, but also on the effective integration of capabilities in inter-regional value chains brings geo-political tensions to the fore. The tension is inherent to the framework presented here. On the one hand, having firms participate in inter-regional value chains is of utmost importance as it opens up many more opportunities to co-innovate and co-produce complex products, while at the same time specializing in the use of particular capabilities within the region. With globalization and the spatial fragmentation of value chains, regions can more and more specialize in specific functions in the production of many different products, leveraging their core capabilities across a variety of value chains. Indeed, the more open a regional economy, the less dependent regional development is on the number of, and complementarities between, the capabilities present in a region (Yeung, 2021; Boschma, 2022). On the other hand, the same openness that supports the complexity of a regional economy, also underlies its dependence and vulnerability. Value chains can be disrupted by spiky commodity prices, new trade restrictions, sudden scarcity of key inputs, wars, or extreme natural events (Brummitt et al., 2017) leading to chaotic dynamics in economic development (Christelli et al., 2015).⁸ In all cases, a region may see its income suddenly drop, and without guarantee that it can bounce back after disruption, given that inter-regional value chains may have been rewired in the meantime.

Conclusions

In sum, the capability framework in evolutionary economic geography views regional economic development as a process of related diversification through the acquisition of capabilities that render an economy more complex. This framework synthesizes seven theoretical notions that had hitherto remained poorly connected: relatedness, complementarity, variety, complexity, diversification, agents of structural change, and related variety

⁸ A salient example of this is the protracted conflict between Russia and Ukraine that culminated in a war. Traditionally, Ukraine had participated in value chains that centered on Russia. However, after the annexation of Crimea, trade between Ukraine and Russia collapsed, forcing a costly reorientation to new value chain connections in Western Europe (Hartog et al., 2020).

However, this framework is restricted by the assumption that regional capabilities constitute both a necessary and sufficient condition for complex products to be developed and produced in a region. We argue that regional presence of capabilities is not a *necessary* condition for the production of complex products, because firms can access capabilities outside the region via inter-regional value chains by connecting to other regions that have such capabilities. We also argue that the regional presence of capabilities is neither a *sufficient* condition to produce complex products, given that the mere presence of capabilities across firms co-located in a region does not guarantee that these firms are able to effectively integrate their capabilities in intra-regional value chains.

We conclude that the complexity of a regional economy depends on the institutions that support firms in coordinating complex value chains *within* and *across* regions. The empirical challenge following from this theoretical conclusion lies in scrutinizing the role of regional, national, and supra-national institutions that support firms in the production of complex products. Analyzing the institutional support that firms, and the production networks they are embedded in, can draw upon should help explain differences in regional development based on how these institutions affect the ability of local firms to develop and produce ever more complex products.

The augmented capability framework also provides an analytical basis for closer integration of evolutionary and relational approaches within economic geography by connecting the capability framework to the theories on clusters, innovation systems, and global production networks. We hope to see more work by economic geographers that combines and integrates these perspectives to further develop evolutionary and relational approaches to regional development in a global context.

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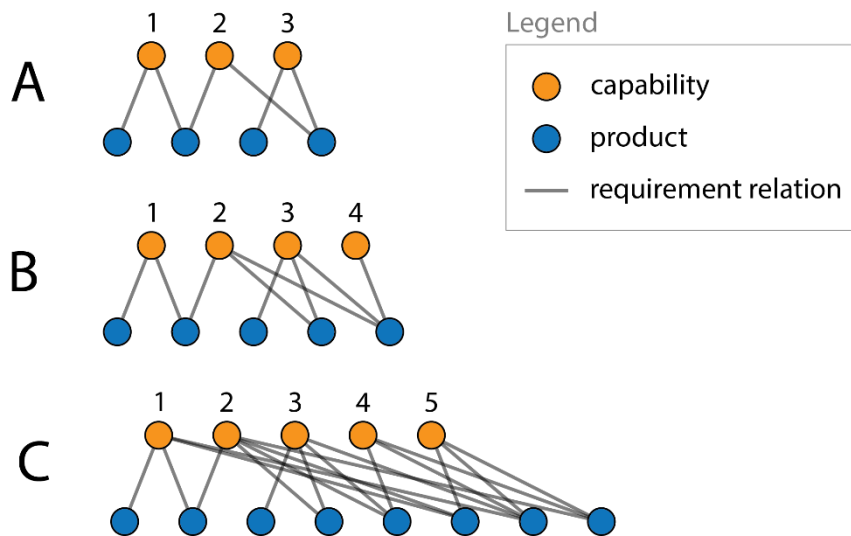


Figure 1. Example of the process of regional economic development: (A) A region with three capabilities and four products. The links between capabilities and products indicate which capabilities are needed to produce a particular product. In this case, the three capabilities in the region can be recombined in four different ways leading the region to produce four products. (B) The region acquires a fourth capability, here increasing product variety from four to five products, as this new capability can be combined with existing capabilities in only one way. (C) The region acquires a fifth capability, here increasing product variety from five to eight products, as this new capability can be combined with existing capabilities in three ways.

$$\rho = 0.75$$

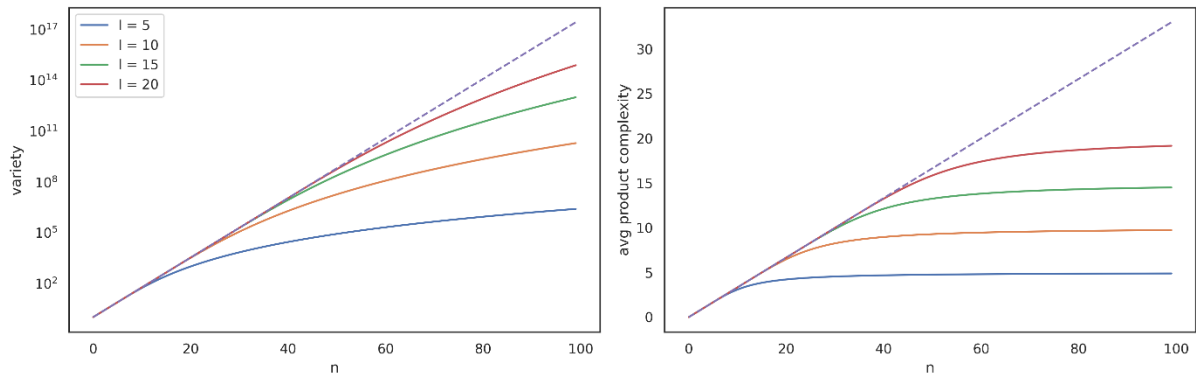


Figure 2. Based on Inoua (2016, 2023) and Van Dam and Frenken (2022), the graphs show how variety and complexity evolve with an increasing number of capabilities n . Parameter ρ is put here to 0.75, and specifies how easily capabilities can be recombined into valuable products (complementarity). Without the constraint of parameter l (dotted line), the variety in a regional economy increases exponentially with $d(n) = (1 + \rho)^n$, and the average complexity of products in a regional economy by $\bar{s}(n) = \frac{\rho}{1+\rho}n$. Extending on the framework by Inoua (2016, 2023) and Van Dam and Frenken (2022), we show here the results for different values of parameter l , which specifies the maximum number of capabilities that can be combined. This parameter reflects a region's quality of institutions. Parameter l thus bounds the maximum complexity of products, and slows down the increase in variety and average complexity once $n > l$. The average product complexity will converge to l as $n \rightarrow \infty$. This shows that regional economic development halts if agents are unable to improve the quality of institutions.