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Regional Development: Challenges, Methods, and Models

Randall W. Jackson
West Virginia University

Geoffrey J.D. Hewings
University of Illinois at Urbana-Champaign

Serge Rey
University of California, Riverside

Nancy Lozano-Gracia
World Bank

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Regional Development: Challenges, Methods, and Models

By

Randall W. Jackson, West Virginia University
Geoffrey J.D. Hewings, University of Illinois
Serge Rey, University of California-Riverside
Nancy Lozano-Gracia, World Bank

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Edited by: Scott Loveridge
Professor, Extension Specialist
Michigan State University

Randall Jackson
Director, Regional Research Institute
West Virginia University

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Contents

The recognition that *aspatial* macroeconomic perspectives can prove to be misleading is far from new, but there has been a recent and welcome increase in attention to the spatial dimensions of economic development. Beveridge (1944) was among the first to introduce a spatial dimension by examining the role of full employment in a society with a special focus on the spatial distribution of employment and unemployment. Readers were startled to find that during the Great Depression (1929-1937), unemployment rates varied by a factor of two to two and a half times between the Southeast of the UK (London-centered region) and Wales, Scotland, and the North of England. The impact of the Great Depression turned out to have been very uneven over space; the Beveridge book sought to understand the causes and the outcomes. Eighty years later, during a period in which a variety of initiatives had been undertaken, the regional disparities have persisted notwithstanding the introduction of significant initiatives by the national government to address these disparities. For the three months ending in July 2017, the highest unemployment rate was still in the Northeast (6.0%) with the lowest recorded in the Southeast of the UK (3.2%).[1] Many other places around the World have experienced similar deep regional inequalities, with disparities between rural and urban areas playing a central role in such inequalities (World Bank, 2014; Deuskar et al., 2015). In China for example, the rural-urban divide is estimated to account for 45 percent of overall inequality (Kanbur et al., 2014).

Much of the disappointment with the outcomes from spatial interventions may be traced to a lack of understanding of how regional economies work. In retrospect, it would appear that many of the initiatives aimed at reducing regional disparities have been proposed with an incomplete understanding of how they might work; in many cases, there was little or no attempt to measure the efficacy of the initiatives. In other cases, the lack of consideration of spatial/regional disparities may have compromised the efficacy of broader development policies. Too often, there is a naïve assumption that investment in a region can only generate benefits or costs in that region; spatial spillovers are, more often than not, ignored. A distinguishing feature of regional economies is their openness, which leads to complex webs of interregional linkages that tie the fortunes of individual regional economies together. This means that one region cannot be studied in isolation from the broader interregional system, and that measurements of interregional linkages and the impacts of these linkages on regional economies are required.

There have been significant changes in the structure of national and regional economies in recent decades that have challenged some of the assumptions on which many regional policy interventions were once proposed. All the while, regional disparities in levels of welfare, growth rates, employment and unemployment have persisted, and one of the major challenges in most countries centers on addressing this persistence. However, earlier views that there is a negative trade-off between national efficiency and regional equity remains current, leading many policy analysts to view attention to regional problems as a cost to overall national growth and development.

The spatial dimensions of economic activity have received increasing attention in the last 20 years (Fujita et al., 2001). Parallel to these developments in economics has been the widespread adoption of geospatial analysis and technologies across the wider social sciences (Goodchild et al., 2000), which reflects the ability of these methods to provide insights as to the role of spatial processes and structure in the operation of many socioeconomic phenomena, and in turn, more comprehensive understanding of the world.

[1] https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/regionallabourmarket/september2017. Accessed 12/04/2018.

In this paper we review the challenges that the consideration of regions brings into economic analysis and provide an overview of some of the key methods and tools that can be used to gain a better understanding of how regional economies work, and through that, identify both the challenges and opportunities that they face. In the next section, the exploration of these challenges begins with some consideration of the ways in which regional economies work to set the stage for subsequent sections that summarize a toolbox of methods and strategies that might be considered for both *ex ante* and *ex post* evaluation of regional development initiatives. In contrast to past reviews of this field, this report presents an integration of more traditional regional macroeconomic modeling with new developments in spatial data analysis.

1 *How Regional Economies Work*

Brakman et al. (2010) suggest that regional economics "... analyzes the spatial organization of economic systems and must somehow account for the uneven distribution (of economic activities) across space..." In contrast, regional growth and development theory attempts to answer three main questions:

- Why and how do regions grow?
- Why do some regions grow more rapidly than others?
- Why do some regions decline?

Unevenness in the neoclassical view of Borts and Stein (1964) would not be a problem since mobile factors (such as labor and capital) would move to extract their maximum rents, leading to a world in which an equilibrium distribution would see no differences among regions. For example, workers would move to regions with higher wages – causing labor market adjustments in origin and destination regions – until wages equalize across regions.

Many of the neoclassical regional models were based on a Ricardian notion of comparative advantage, in which a region exports those goods that it produces at relatively lower production costs that result from differing relative productivities of the factors used to manufacture the goods. It is trade in goods or factors, adjusting through their relative prices and increased productive capacity, that results in the achievement of full employment. In this world, differing remunerations of the production factors reallocate resources in space, and thus generate a higher rate of growth and eventually, in equilibrium, equalized factor returns.

However, factors are neither infinitely divisible nor homogenous and certainly not perfectly mobile. This leads to non-equilibrium outcomes in which differences in levels of welfare between regions can arise and persist. So, what happens when mobility is limited, and instead of constant, there are increasing returns to scale, with differing initial endowments and number of sectors in each region?

According to Richardson (1978), regional growth economics differs from aggregate growth theory by its emphasis on interregional factor mobility as a key growth determinant; neoclassical regional growth models simultaneously offer explanations of endogenous system of growth and interregional factor flows with a single model. However, as regional economics developed, it became clear that many of the assumptions in neoclassical theory were difficult to envisage operating in reality; in fact, Armstrong et al. (2000) advance the notion that one of the reasons that regional development policy can be justified is to address market failures.

Among the many critical assumptions of traditional neoclassical models, is the one that a common wage level prevails in ALL regions because of perfect adjustment on the demand side due to differentials in labor supply growth. However, frictions to the mobility of labor are common in many parts of the world. Further, in some regions, labor supply grows faster because of a faster rate of natural increase and/or net migration, and this faster increase in labor supply or barriers to mobility of factor markets can have a dampening effect on wage rates and can prevent equalization of wages.

Under the assumptions of the neoclassical model, even if a region produces all goods at higher prices, so that it is generally more inefficient in its production processes than any other region in the country, it may nevertheless be relatively less inefficient in producing one particular good. The region will thus be able to obtain a role for itself in the international division of labor by specializing in the production of the good in which it is *relatively* more efficient. As Capello (2015) has noted, this argument has major normative implications, for it asserts that there is always an automatic mechanism guaranteeing the existence of some specialization, regardless of productive efficiency, and therefore economic policy measures to foster development are unnecessary.

However, it is the imbalance in interregional factor endowments, and differences in levels of factor productivity, that account for the advantage enjoyed by a local system in its relations with the rest of the world. These are the elements that underlie a region's growth path and condition its timing and the form that it takes. Capello (2015) notes that there are numerous sources of territorial competitiveness: one of the main foci has been on role of differences in factor endowment as the main source of territorial competitiveness.

More generally, many of the limitations of the neoclassical model and its reliance on automatic equilibrating mechanisms stem from two assumptions: that (1) the capital market is perfect; and (2) technical progress is available to all regions – no one region has an advantage. Under these assumptions, the outcome is convergence in regional incomes. However, empirical evidence refutes the conclusion that capital flows to regions with low income levels. And instead, most countries end up divided into leading regions where investment and economic activity concentrate, and lagging areas where investment remains low, economic activity is incipient, and basic living standards are lacking.

An alternative approach that would furnish a better interpretation of the real movement of the factors would confirm the tendency of capital to shift to areas with higher wage remunerations; in this alternative approach, often referred to as the Two-Sector model, subsequent reallocation of resources, due to an external shock that moves the regions far from the initial steady-state equilibrium, pushes local economies towards permanently different growth rates.[2]

Consider a two-region case and assume an initial equilibrium, with the growth rate stable and uniform between the regions and in which capital and labor grow in each of them at a constant rate equal to that of income. Now consider an exogenous shock, for example, wherein the demand for the good exported by one of the two regions increases. The price of the good rises as a direct consequence and this effect has a positive impact on the value of the marginal product of the factors in the region. The outcome is an intra- and interregional reallocation of production resources. The amount of capital stock increases in the producing sector to meet the increased export demand because of the inflow of external capital attracted by greater returns. However, labor demand by local firms will also increase because of the increase in the value of the marginal

[2]Recall that the neoclassical model has production factors migrating because they are attracted by higher remunerations.

product of labor (generated by the rise in the exported good price). There will be two further effects, one generated by in-migration and the other by labor switching. The greater demand for labor will attract workers both from the local agricultural sector and from other regions, given the higher remunerations that will be available. Expansion of production and employment in the sector producing for export will thus have a *backwash effect* on the agricultural sector. The main outcome is regional divergence — the persistently higher growth rate in the region for which export demand is increasing generates attractive forces — for both labor and capital — that make it difficult to envision a situation in which the agricultural sector will "catch up" in terms of income convergence, without additional interventions. While the less prosperous regions offer advantages due to their relatively lower wages and unit labor costs, these are often not sufficiently attractive for significant relocation of economic activity.

Persistence of marked regional disequilibria suggests that these locational advantages are not enough to close the gap between advanced and backward regions. The more prosperous areas are able to absorb the decreasing returns that accompany industrialization and high capital intensity, while the less prosperous regions of the advanced countries (such as those regions in the new accession countries of the EU) have to compete with the low unit labor costs characteristic of the developing countries. These issues highlight an emerging problem in regional analysis – the existence of differences at different spatial scales (e.g., EU versus the developing world at one level, differences between regions within the EU and even important heterogeneity within regions, for example between urban and rural areas, and even within neighborhoods in a city).

Further, within a country, the economic performance of a region depends largely on its absolute rather than its comparative advantage. A negative shock in a national sector is often met with real depreciation, which continues until other sectors become competitive. Within a country, labor markets are often more integrated than across countries, and hence if a region suffers a negative shock, flexibility of adjustment of relative wages will be lower making equalization of wages harder. Prices of immobile factors like land and housing may decline but this may not be enough to bring the local economy to competitive levels, suggesting persistent regional disparities and possible loss of labor rather than the convergence mechanism often expected at the national level (Duranton and Venables, 2018).

Another issue not addressed by the neoclassical model is the difficulties of factor flow movements, since the model assumes that the costs of migration are zero, when migration costs can often be high. This will be true not only of labor, but also for firms -– especially those whose production systems require significant investment in buildings and associated infrastructure. In addition, full information may not be available and even when available, Basile and Lim (2017) have identified a non-linear relationship between migration and wage differentials, with an "inertia range" in which little migration is observed until the differentials become large enough that people do move. One might appeal to the role of assets or access to credit as an important part of the decision-making process in making a move. Capital, even if mobile, may remain in more prosperous regions because of cumulative processes, information spillovers relating to innovation and other factors that the New Economic Geography (NEG) groups into agglomeration forces. Further, labor may not be able to move from agriculture to industry because of lack of skills generating the possibility of wages increasing in one sector even with high unemployment in the other. While the two-sector model has still some limiting assumptions, it does move the discussion closer to empirical realities and toward a better understanding of the specificities of regional economics.

Regional analysis has reached a stage in which theory has formed the foundation for a better understanding of how spatial development happens, incorporating some of the frictions that we see

in reality and that neoclassical theory ignores. Yet, regional economic development theory still falls short of complete spatial-awareness – of explaining both why and where things are happening. Policy proposals for regional development have followed a similar process of "evolution," sometimes developing hand in hand with theory and sometimes despite it. In the next section, a brief review of some past and current policies will be provided, all premised on the notion that market failure, in the form of uneven development, requires some form of intervention.

1.1 An overview of policy proposals

In the 80 years since the publication of Beveridge's monograph there has been a variety of regional policy proposals aimed at the reduction of interregional disparities. Many of these have focused on limited development in more prosperous areas while others focused on enhancing the competitive potential of the least prosperous regions of a country. An excellent but somewhat dated overview may be found in Armstrong et al. (2000) with some of the more recent policies reviewed by McCann (2015), with a special focus on the United Kingdom and the European Union.

The Early Regional Policies-Sticks and Carrots

In the 1960s, especially in the United Kingdom, regional policies oscillated between those termed "Carrot" and those characterized as "Stick." The former provided incentives for firms to locate establishments in less prosperous regions; these incentives ranged from outright grants to tax abatements and funds for the training/retraining of employees. In analysis of the Department of Regional Economic Expansion policies in Canada, Woodward (1973, 1974, 1975) characterized these policies as windfalls; in many cases, the firms had already decided to locate in less prosperous areas (especially in the Atlantic provinces) and so the incentives provided little benefit to these economies but were clearly attractive to the firms (see a more recent comprehensive evaluation by Schofield (1989) and Polèse and Shearmur (2006a,b). In contrast, the stick policies were focused on restricting development in the most prosperous parts of the country (e.g., London in the United Kingdom). The argument advanced was that without such restrictions, firms would continue to place establishments in these regions and thus exacerbate the already profound existing disparities. Neither policy was particularly effective, and few countries adopted the restrictive policies, but many continue to offer subsidies and incentives for firms to locate facilities in their region (referred to globally as "fiscal wars" such as the one recently visible in the US for the location of Amazon's second major headquarter facility). Rarely, does one find careful project appraisal techniques being used to evaluate the expected return on investment by public agencies although US states are becoming more assertive in tying incentives to a set of demonstrable metrics (e.g., numbers of jobs created).

Growth Poles and Growth Centers

The fascination with Perroux (1955) concept of *pôles de croissance* (growth poles) generated a new wave of interest in the creation of innovative policies that address regional disparities. Since Perroux's concept was *aspatial*, proposing to exploit the dynamics of critical linkages in an economic system, it was quickly translated to the term *growth centers*. However, like Perroux's original concept, definition proved elusive to the point that growth centers were often designated *ex post*. What was retained was a sense of the role and importance of sectoral linkages, building on

some of the early ideas of the notion of keys sectors (Hirschman-Rasmussen). One of the main problems of this set of ideas is that they looked to the past rather than providing indicators about the future growth and development potential of a region (on this see Diamond, 1974).

Portfolio Theory

For a number of years, regional development strategy became enamored with an industrial policy analogous to financial portfolio theory in which the explicit trade-off between risk – unemployment volatility in the industrial case – and return – employment growth by industry – was applied to regional economic systems. The region's industrial portfolio was to be viewed as though it were a stock portfolio, which was then evaluated in terms of two dimensions – the expectation for growth and the risk associated with public capital investment in the sense that a faster growing sector might also be one that experiences significant cyclical behavior (e.g., boom followed by bust). The mathematical programming portfolio variance techniques already in application in finance could then be applied to seek a mix of industries that would provide an acceptable balance between risk (economic fluctuations) and return (growth rates). Policy makers could indicate preference for risk minimization by supporting the development of industries whose employment fluctuations were countercyclical and offsetting, or for more rapid growth with less concern for employment or unemployment volatility. Following its introduction by Conroy (1974), the approach attracted support from early proponents such as St. Louis (1980) along with some additional commentary and criticism offered by Jackson (1984). The idea seemed to have experienced a modern renaissance with work by Chandra (2003) and Chiang (2009) but has been eclipsed by the cluster-based strategy most closely associated with the work of Porter (1990).

Industrial Complexes and Cluster Strategies

In regional science, there had been an emerging tradition in industrial complex analysis in which attention was directed to the interconnections between industries within some a priori defined geographic space (see Czamanski, 1971; Czamanski et al., 1974; Czamanski and Czamanski, 1976 and Czamanski and Ablas, 1979). The influence of Marshallian ideas of industrial districts and the externalities they generate was also influential but, as Martin and Sunley (2003) have noted, Porter was perhaps not as generous as one might have wished him to be in acknowledging the intellectual foundations of his proposals. Porter's initial ideas centered on a diamond of interactions within a local context – firm strategy and rivalry, factor inputs, demand conditions and related and supporting industries. The latter three components could be found in Czamanski's work, for example, while Porter's addition of firm strategy and rivalry clearly differentiated his work from traditional academic endeavors and positioned him to command the attention of national and regional governments eager to embrace a new strategy for enhancing competitiveness. Martin and Sunley (2003) also reflect a growing sense concern about a concept that has not been rigorously evaluated. While this is a valid concern, it applies equally to virtually all development strategies. While the relationships between structure and performance can be assessed, on this basis alone one cannot really conclude anything about whether there was an *explicit development program* that had consequences consistent with the observed relationships or changes. In fact, extensive searches of the literature fail to produce evidence of rigorous evaluations – for example, the adoption of some quasi-experimental design in which two similar regions, one with and one without a cluster-based development strategy, could be compared in

terms of some appropriate metrics of economic performance.

This is not to suggest, however, that there is evidence suggesting the failure of cluster development strategies. Indeed, cluster strategies themselves are often not formally defined (Yu and Jackson, 2011), and can include any combination of state-sponsored efforts, groups composed of private entrepreneurs working to enhance interindustry linkages, actively promoted cluster initiatives, and clusters that have developed essentially organically, with the most prominent example of the latter kind being Silicon Valley. Woodward (2012) describes the success of the South Carolina auto cluster, which continues to gain momentum, and there is anecdotal evidence that many other cluster initiatives have been successful. Cluster initiatives vary from case to case, of course, complicating their evaluation and assessment. The most substantial contributions from some cluster initiatives can simply be the establishment of and focus for networks of like-minded individuals working toward a common goal. Cluster-based initiatives that engage more and more diverse actors in their networks, such as academic institutions, chambers of commerce, governmental bodies, and private entrepreneurs would be expected to be more effective than those that engage fewer, but again, empirical assessment is lacking.

The Role of the Creative Class: A New Take on Key Sectors

Similar criticisms surrounding a lack of evidence-based support might be directed towards Florida's (2005a) exposition of the role of the creative class; in his book, he proposes that while "... the role of creativity in city formation and growth is new, ... with the decline of physical constraints on cities and communities in recent decades, creativity has become the principal driving force in the growth and development of cities, regions, and nations." As with many concepts that focus on a subset of a regional or urban economy, there is always going to be criticism directed to ignoring or downplaying the role of the rest of the economy. As Diamond (1974) once commented in connection with the concept of key sector analysis (of which the creative class idea shares many conceptual similarities), a case may be made that non-key sectors may be more critical since, without them, the key sectors would not be so prominent. A more nuanced vision of an economy might appeal to the one proposed much earlier by Leontief who highlighted the roles of circulation and interdependence and drew attention to the notion of complexity generated by consideration of not only direct relationships but the importance of indirect ones (something not considered in Porter's work).

Smart Specialization

More recently, there has been interest in capturing some of the characteristics of earlier policies within a more comprehensive framework that is referred to as *smart specialization* (see McCann, 2015). Conceptualized as a new way to integrate innovation and development policy, the proposed strategy was motivated by concerns about the productivity gap between the European Union and the United States that could be traced to the former's weakness in the diffusion of new knowledge and technologies across sectors. The causes postulated included (1) differences in labor markets; (2) management performance; (3) organizational issues and (4) market deregulation. According to McCann (2015), the key turned out to be the critical role played by new information and communication technologies (ICT)since it was ICT-producing sectors that were driving the productivity gap. Smart specialization was originally a non-spatial construct – focused on the idea of a knowledge ecology – the endogenous context in which technological evolution takes place,

focusing on pathways for innovation, the evolutionary experience of the system, inherited structures, institutions and actors and their interrelations. In addition, it focused on the role of entrepreneurial search processes and the domain in which innovation takes place especially its connectedness, thus highlighting the role of R&D in the broadest sense.

Further, smart specialization highlighted the role of *domain*, relevant size (scale economies) and level of connectedness and in this sense drew on ideas from NEG – but with much greater focus on the relatedness of varieties. It appealed to the attraction of Marshallian externalities, namely that it would be easier to switch between related than between unrelated activities (in response to changes in demand). All these attributes needed to be embedded in the domain – with a focus on local linkages, dependence on local skills or local institutions.

Connectivity highlights the degree to which firms are linked within the domain via transport, interpersonal and financial links. The policy implications stress the proposition that in order to foster innovation and growth, regions should prioritize those activities enhancing entrepreneurial search activities to diversify those that are highly embedded in the region. There should be a concerted attempt to build on existing dominant technological and skills profiles and capabilities but then diversify around this core base. While this proposal might be appropriate for those regions that actually have dominant tech and skills profiles and capabilities, it would be difficult to translate into action in places that lack them – such as NE Brazil, perhaps, or even a state such as West Virginia in the US. Empirical evidence suggests that regions grow more successfully and are more resilient if their growth patterns are more related to their historical trajectories. Hence, in contrast to portfolio theory, the diversification strategy is more nuanced in that it does not posit a sharp break with prior specialization. Smart specialization does not imply regions should become more specialized because this will make regions more vulnerable to shocks. In essence, regional policies should promote not just diversification but *specialized diversification*. Particularly astute are the obvervations of Malizia and Feser (1999), who note that, "The economic diversity of a city can be defined in reference to its specializations. As additional relatively independent specializations co-locate, the area becomes more diverse. Economic diversity is the presence of multiple specializations." In response, Jackson (2015) developed a method designed to identify new activities that move the regional economy toward specialized diversification. This approach contrasts with some earlier attempts to explore diversification to provide some pro-active counter-cyclical resilience in regions that were characterized by a relatively narrow economic base. For example, in an evaluation of a diversification policy for Appalachia, there was no consistent superior performance in counties that were more diversified than others. In many cases, the more diversified counties had become that way as a result of the loss of specialized industrial activity rather than through the addition of firms in other sectors. Indeed, Chinitz (1961) urged the careful assessment of how changes in one industry might impact regional suitability for others. Chinitz fell just short of explicitly identifying a paradox for the structure to performance relationship. "Namely, should an anchor industry in a region suffer a sharp decline, the region by most measures would as a direct consequence become more diversified, though certainly not better off" (Jackson, 2015, p. 119).

Whatever polices that are proposed, there is a concomitant need to provide an analytical framework that can be used for evaluation. Evaluation is significantly underrepresented in the literature in large part because of the difficulty of demonstrating that policy x has made a difference. Single-equation analysis (e.g., Moore and Rhodes, 1974) is clearly not complete and the difficulties of comparative analysis remain. Further, as regions become more interconnected, comparison based *only* on internal structure fails to highlight potential differences in external

linkages. In subsequent sections, a set of available models and approaches that could be used for policy analysis will be identified.

Academics and policy makers are reluctant to highlight failures – and as a result, many policies continue to be recycled despite their often-limited efficacy. Additional work is needed to assess what has been learned from previous policies about what did and did not work. What made a difference and in what ways? How did the outcome vary by the type of intervention, such as a direct impact (e.g. a grant or subsidy) or an indirect one (infrastructure, investment in human capital etc.)? What were the positive and what were the negative impacts of demographic changes (aging, composition of the labor force, migration, occupational/skill capital) and economic development? An example of such assessment is done in recent work by Rodríguez-Pose and Wilkie (2018) where a series of policies to promote growth and development in underperforming, lagging areas is reviewed and evaluated through a critical discussion of the impacts of such policies. However, much more empirical evidence is needed to build a body of work that can suggest with confidence which policies have had the desired impacts and which have not.

1.2 Avoiding "one size fits all" pitfalls in terms of diagnosis and policy prescriptions

One major theme that has emerged from the regional policy literature is that there are no universal approaches that seem to work in all places. In large part, this problem can be traced to the idiosyncratic nature in which national and regional economies interact, their history and traditions, the nature and strength of government institutions and the degree to which notions of fiscal decentralization have been adopted.

One common suggestion could be advanced, namely that before any policy is adopted, a careful appraisal of the structure of the regional economies would be necessary. While this might seem self-evident, there are many cases of policies being adopted prior to a diagnosis of the structure of the regional economy. In the next section, a rational for this diagnosis will be presented; thereafter, the discussion will move to a consideration of regional structure and some of the methods that can aid in diagnosis and interpretation.

2 *What Have Regional Policies Missed?*

2.1 Critical nature of internal heterogeneity

Beveridge (1944) identified the nature of the internal heterogeneity of the United Kingdom economy, a phenomenon that has persisted in almost all countries. The enormous expenditure of funds provided by the European Union for cohesion policies provides further testimony to the critical nature and persistence of inequalities in the level of welfare both across and within countries. As noted in the previous section, it makes little sense to discuss the development of a country such as Brazil without providing concomitant detail on the internal spatial distribution of economic activity and population. To gain a deeper understanding and appreciation of heterogeneity within countries and across regions, it is key to look at dimensions such as the trade of goods, services and people as that provides a sense of the strength of linkages among interconnected regional economies. Innovations and income transfers will also reveal critical

aspects of interregional knowledge and resource linkages. Further, assessing geographical, cultural, social, and infrastructure availability differences can also shed light on where disparities in living standards stem from and provide an avenue for breaching existing gaps.

2.2 Identifying spatial interconnections-trade in goods and services, trade in people, innovations, interregional income transfers

Modern production systems have become increasingly more fragmented in recent decades, with different phases in production systems often allocated to different geographical locations. As a result, interregional and international trade flows have been growing at rates in excess of the corresponding rates of growth of gross regional or national domestic product; further, this trade is increasingly dominated by *intra-industry* rather than *inter-industry* trade, reflecting the exploitation of economies of scale in production of specified components and the significant reduction in transportation costs that facilitate spreading production across different locations along the value chain (Krugman, 1991). This process has been propelled in part by a significant spatial reorganization of value chains over the past two or three decades, and the concomitant logistical issues associated with the most efficient coordination of production systems has generated a complex system of interdependent flows, linking regions in one country with regions in another.

This process of hollowing out (namely, the substitution of external sources of inputs and sales for intraregional transactions) has seen *intra-economy* multipliers decreasing while *interregional spillovers* are increasing; this phenomenon is occurring at both the interregional and at the international scale. Hence, one can no longer assume that a similar project would generate the same spatial and total impact wherever it was located within the nation at hand. The development of multiregional input–output and computable general equilibrium models has revealed that, contrary to Friedman (2005), the world inside nations is not flat; space is spiky and it is uneven (see Florida, 2005b). Further, projects generate different spatial distributive impacts depending on the nature (highway, new business, investment in human capital) and on the location of the project. In addition, spillover effects are not necessarily symmetric: a project in Cataluña might generate larger impacts on Madrid than a project in Madrid generates on Cataluña. Major projects can disturb the spatial equilibrium as factors such as capital and labor respond to changes in opportunities and rents by relocating.

As the processes of fragmentation and hollowing out continue, interregional dependency will assume even greater importance in explaining the growth and development paths of economies. The tragic events in 2011 in Fukushima, Japan (earthquake and tsunami) and in Thailand (floods) revealed risks associated with extensive supply chains that reach across many widely spread locations and showed that disruptions in even the smallest components can generate severe stress on the whole productive system.

Regional economies are becoming both more *competitive* and more *integrated/complementary* at the same time, creating new challenges for policy analysts. To understand these new challenges to economic development, it is essential to develop and maintain tools – such an interregional input–output models – that can assist in tracking these changes; focusing on just one region can generate misleading outcomes. As in almost all formal economic modeling, the distinction between endogenous and exogenous is very important; in constructing single-region models, it is often assumed that the impacts of exogenous change are of a top–down nature with no feedback effects.

However, the changing structure of regional economies has resulted in greater role for interregional trade and the possibility that feedbacks could prove to be important.

In this context, attention to trade needs to be expanded from attention to goods and services to people, ideas and information flows. In many cases, movement of people (e.g., out-migration) can often exacerbate the challenges of a less prosperous economy as Vanderkamp (1971) noted many years ago.

The field of spatial econometrics has developed an increasingly sophisticated set of tools to help identify the nature and strength of interregional spillovers to complement some of the more traditional interregional models that can now be constructed relatively easily.

2.3 Addressing socio-cultural barriers and increasing concerns about increased inequality

The publication of *Capital in the Twenty-First Century* refocused attention on the role of inequality within nations (Piketty, 2017); but many prominent scholars, such as Stiglitz (2012) and Atkinson (2015) have provided rigorous commentary on the impact of inequality. Piketty's major contribution was to stress the role of the differential between returns to capital in contrast to labor as a major source of increasing inequality. However, these discussions usually focus on interpersonal inequality, rarely mapping the outcomes into a spatial context. There is no consensus about how inequalities should be reduced and the measurement of the "cost" of inequality is still not generally accepted. Appeals to broader definitions of welfare that extend beyond monetary considerations are often used to justify some form of intervention to address inequalities.

2.4 Challenging the regional equity-national efficiency trade-off – solutions to some regional problems may enhance national efficiency

Regional analysts have been exploring the nature (and even the existence) of a trade-off between attention to regional problems and the impact this might have on national economic efficiency. Archibald (1969, 1972) was one of the early contributors exploring this apparent trade-off, and subsequent work by Thirlwall (1969, 1970), Mera (1967, 1973) and Thirsk (1973) found that the simple expectation of a trade-off was often not confirmed in empirical work. In fact, Higgins (1973) was more forceful in suggesting that:

> Measures to reduce regional gaps, far from being a "luxury" to be afforded when things are otherwise going well in the country, are the essence of a policy to accelerate growth, reduce unemployment and maintain stability. For developing countries, where efforts to accelerate growth are inhibited by fear of aggravating inflation, reduction of regional disparities may well be the *sine qua non* of a successful development policy.

National and subnational policies necessarily differ for a variety of reasons. Prominent among these differences is that there are many fewer policy handles available to regional policymakers than there are to national policymakers. Regional policymakers have no control over macroeconomic variables like money supply or interest rates, they cannot regulate trade or migration, and they typically have smaller amounts of and less discretion over funds that might be transferred from one to another sub-region. Because regional officials have much less control over cross-border transactions, they find themselves in the role of price taker rather than price maker.

Regional economic systems are typically much more open than national economies and depend on other national sub-regions for inputs to their production processes, the provision of consumption and investment goods, and for markets for the goods and services they produce.

As a result, policies at the regional level often focus more heavily on structural economic characteristics on the one hand, and on social and economic infrastructure on the other. The healthiest and most vital interregional economic systems are composed of healthy and vital regional economic systems. For this reason, the starting point for most analyses of regional systems is focused on regional structure. Most structural analyses address industrial structure, labor force characteristics, and household income and demographic characteristics.

3 *Exploring Regional Structure*

Understanding the economic structure of a region can help understand where its development potential lies, and where the key bottlenecks to growth might be. Better understanding of the economic structure of a region can also help diagnose which links with other regions are more important, where coordination is essential, and where important links might be broken and need attention. To demonstrate some of the key characteristics of interregional systems that support taking a regional and multiregional structural approach to national policymaking, consider the following idealized 3-region example. The three regions, I, II, and III are of decreasing size and socioeconomic conditions, as reflected by per capita value added (see table 1).

Table 1: Three Regions: Summary Characteristics

Region	Population (millions)	VA (millions)	PCVA
I	10	450	45.0
II	9	308	34.2
III	8	258	32.3
Nation	27	1016	37.6

By fully aggregating industry transactions, we can present the interregional accounting system in Table 2 where the interregional transactions can be seen in the upper left 3x3 quadrant, denoted Z, and in coefficient form in matrix A.

Table 2: The Structure of Interdependence

	I	II	III	Y
I	320	63	48	569
II	40	210	54	396
III	50	28	168	354
VA =	450	308	258	
Imports	140	91	72	
X =	1000	700	600	

A =

0.32	0.09	0.08
0.04	0.30	0.09
0.05	0.04	0.28

The diagonal values in Z are aggregations of all interindustry transactions that take place within the regions, and the off-diagonal cells show between-regions aggregations. Value-added is presented here is a single VA row, but is an aggregation of employee compensation, payments to government, and gross operating surplus. Gross output, X, equals the sum of payments by industries in the region to intermediate suppliers, to value-added, and to the rest of the world for

imports. The financial units here can be thought of as thousands of dollars for purposes of discussion, but the relationship between financial units and population could be scaled differently to reflect actual national development levels without loss of generality. This example was constructed in a way that would be consistent with nations that are composed of larger, more developed and typically more urbanized regions, and successively smaller and less developed regions. Such nations typically have a large urbanized area for which productivity is higher and per capita incomes are likewise higher than in the two smaller, less urbanized or more rural areas.

The interregional multiplier matrix (Table 3) for this national system is similarly representative. Intraregional multipliers decrease from 1.5 in Region I, the largest and most developed region, to 1.45 and 1.39 in the smaller regions. Although the example was deliberately constructed to demonstrate the potential for enhancing socioeconomic conditions in the lagging regions without sacrificing national equity, the trade relationships shown are not unreasonable nor out of the ordinary. Region I is an important supplier for all regions, and it purchases much more from itself than it does from the other two regions. Likewise, Region II purchases more from dominant Region I than it does from Region III, and Region III purchases almost equal amounts from both regions.

Table 3: The Interregional Multiplier Matrix

	I	II	III
I	1.50	0.20	0.19
II	0.10	1.45	0.19
III	0.11	0.09	1.39
Multiplier	1.70	1.75	1.77

We take the position here that the interindustry and inter-regional industrial structure and trade relationships play a critical role in determining the effects of various policies and programs. To underscore this proposition, we turn our focus to the commonly proffered argument that there is an inevitable trade-off between national efficiency and interregional equity, and that to enhance the latter requires sacrificing the former. Using this simple numerical example, we demonstrate that it is indeed possible, as suggested in Section 2.2, to enact policies that can target economic enhancement in lagging regions in ways that not only do not sacrifice national efficiency, but actually enhance it.

Our policy scenario is as follows. Assume that we have a national budget to support expenditures in the amount of $90k. Such an expenditure of public capital might be channeled to physical infrastructure, to educational infrastructure, or even direct assistance. Now, because productivity as measured by value added per capita (PCVA) is highest in Region I, conventional wisdom might suggest that focusing the public capital expenditure in the most efficient region would have the greatest impact on aggregate efficiency, as measured by increase in value added. To demonstrate that this is not a foregone conclusion, we use three scenarios, one that represents each extreme position, with all $90k invested in Region I or Region III, and an intermediate scenario in which each region receives equal shares of the public capital investment, as shown in the table 4.

Table 4: Scenario Development

	Regional Expenditure Distribution: Scenarios A, B, and C		
	A	B	C
I	90	30	0
II	0	30	0
III	0	30	90

The impacts assessment outcomes are shown in table 5 below. As expected, value added impacts are greatest in the investment regions for the two extremes, and when the investment is spread evenly over all three regions, the impacts are directly correlated with pre-shock development levels.

Table 5: Impact Results

				VA Impacts by Scenario			PCVA Impacts by Scenario		
Region	Popn	VA	PCVA	A	B	C	A	B	C
I	10	450	45.0	60.6	25.5	7.8	6.1	2.8	1.0
II	9	308	34.2	3.9	23.0	7.6	0.4	2.6	1.0
III	8	258	32.3	4.2	20.9	54.7	0.4	2.3	6.8
Nation	27	1016	37.6	68.79	69.43	70.07	2.29	2.57	2.92

However, contrary to conventional wisdom, the distribution of public capital investment that generates the largest value-added impact is Scenario C, in which the entire investment is targeted to Region III, the one with the lowest PCVA. This also is the scenario that results in the strongest convergence in PCVA across regions, and the greatest national PCVA value (see table 6).

Table 6: Modified Results

				New PCVA by Scenario			Percent Change in PCVA		
Region	Popn	VA	PCVA	A	B	C	A	B	C
I	10	450	45.0	51.1	47.6	45.8	13.5%	5.7%	1.7%
II	9	308	34.2	34.7	36.8	35.1	1.3%	7.5%	2.5%
III	8	258	32.3	32.8	34.9	39.1	1.6%	8.1%	21.2%
Nation	27	1016	37.6	39.50	39.73	39.98	5.0%	5.6%	6.2%
			6.9	10.1	6.8	5.4			

The lessons that we draw from this exercise can be summarized as follows:

1. The structure of interindustry interregional trade within a nation plays a vital role in determining impacts of policies and programs on each region and on the nation.
2. Investments in one region will have impacts on all regions.
3. Whether a nation must sacrifice efficiency in exchange for increased interregional equity will depend upon the intra-and inter-regional interindustry structure of that national system.
4. Altering the structure of intraregional trade can have dramatic impacts on own-region multipliers and system-wide effects.

To further illustrate this final point, consider the following scenario in which, as a result of import substitution, Region III increases its intraregional dependency, as reflected by an increase in its diagonal value from 0.28 to 0.31. Making this single change while holding all else constant in

Scenario C results in a 4.4% increase in both the regional and national value-added impacts values. Likewise, strengthening interregional trade can have substantial impact. Doubling Region I's relatively small purchases from the other two regions increases the value-added impact by 1.75%.

Together, these examples indicate that a) a comprehensive understanding of the geographical distribution of national policy impacts requires an understanding of interregional inter-industrial structure. The positive impacts of policies and programs can be targeted to specific regions, and relative distribution of benefits across regions can be affected by careful structuring of national programs. Therefore, there is great value in developing a systematic approach to the altering the characteristics of regional structure that can have the greatest effect on regional and national development. The analysis of regional industrial structure is the topic of section 4.

The purpose of the example in this section has been to demonstrate that there is a variety of outcomes that are possible given alternative public capital investment scenarios and public policies. It is also undoubtedly clear that the specific outcomes that will be observed depend heavily on the detailed structure of regional and interregional economies. Every summary value in the example scenario embodies a number of characteristics and details that would require much greater specification and accuracy for any real-world application. Different industries have different input requirements and output distributions, they have different ties of different strengths to other regions, and their value-added payments are distributed differently, not only among the major categories of compensation, payments to governments, and gross operating surplus, but also to different household categories. Labor force requirements create differential demands on households of different types and income levels, and different demographics. And these are just some of the many detailed characteristics that require explication when analytical models are constructed for assessing alternative policy outcomes.

Additionally, moving beyond those regional and interregional characteristics that can be captured in interregional accounting frameworks, other regional traits and behavioral differences can and do moderate the ways in which policy outcomes play out from region to region. Differences in natural resource endowments and amenities often define and constrain the development path. Differences in regional consumption savings rates, for example, can have a dramatic influence on the flow on effects that play a critical role in determining the total impacts of policies. Likewise, whether savings translates to investment within or outside a regions' borders will strongly shape the developmental impacts of increased income, savings, and investment.

Other factors that will shape policy outcomes include the extent to which development may be aided by external economies of scale and agglomeration, by cultural norms that will influence educational and hence occupational skill levels, labor force participation rates, family structures, the prevalence of crime and other social maladies that often arise from increasing density and congestion.

In the next section, a more comprehensive review of some regional analytical methods will be provided, after which attention will be directed to methods of exploratory spatial data analysis.

4 *Regional Economic Analysis Methods: Introduction and Selective Overview*

At the most fundamental level, a complete description of regional economic structure begins with an inventory of employment, compensation (wages and salaries), and output by industry. This information contributes to economic understanding in at least four ways. First, it is useful to know how specialized or diversified the regional economy is. A long-standing concern at the regional level is overspecialization that makes a region susceptible to industry-specific national and global economic downturns. Consumer tastes and preferences and industrial production needs shift over time, so regions that are too highly specialized can suffer traumatic consequences if industries on which they depend experience rapid declines in demand. Second, by identifying relative concentrations by industry, we can begin to assess regional comparative advantages. Industries that fall into this category become candidates for further analysis, assessing their futures and potential for further development, not only within these specific industries, but also in related industries that are strongly connected by direct and indirect forward (sales) and backward (purchases) linkages. Third, a comprehensive inventory of activities becomes the foundation for behavioral models that can be used for assessing economic impacts of policy changes, positive or negative economic disruptions, and consequences of public capital investments. These models can be used to anticipate and understand regional economic system responses in terms of changes in employment and wages, occupational demand, and changes to household income distributions. Fourth, models of individual regions can be linked with other regional models to develop a better understanding of how regional fortunes are intertwined.

4.1 Regional Economic Systems Inventorying

In this section, we provide a brief overview of a set of fundamental methods that most often form the initial assessment of regional economic structure. The first set – largely composed of quotient-based metrics – focuses solely on description, while the second set lays the foundation for prospective interventions by incorporating either a temporal or behavioral element.

The Location Quotient

The location quotient, or LQ, is a very simple metric that is designed to compare a distribution of shares, or concentrations, with a reference distribution. In regional analysis, it has most often been used to assess concentrations of industries by focusing either on regional employment or regional income by industry relative to the national distribution. In this case, the industry share of national total is used as a meaningful comparator for subnational regions, so industry LQs can be directly compared across regions. An example would be to compute LQs for variable x (e.g., employment or income in industry i) as

$$\frac{\text{region's share of national } x_i}{\text{region's share of national } x} \quad \text{or} \quad \frac{\text{regional } x_i/x}{\text{national } x_i/x}$$

Using employment as the interest variable, the first expression carries the interpretation of the region's share of national employment in a specific industry relative to the region's share of total employment, and the second expression is expressed as the industries share of regional employment

relative to the region's share of national employment. Although the objective for a given analysis might lead to a preference for one or the other expression, their mathematical equivalence is assured, as is their interpretation. LQ values greater than 1.0 indicate relative regional industry concentrations, and values less than 1.0 indicate concentrations smaller than the national average.

More formally, in terms of employment, the location quotient for industry i is defined as

$$LQ_i = \frac{e_i/E_i}{e/E} = \frac{e_i/e}{E_i/E} \qquad (1)$$

where

ei denotes regional employment in industry i,

Ei is national employment level in industry i,

e is total regional employment,

E is total national employment.

While there can be many explanations for high and low concentrations of industries in a given region, high LQs suggest regional comparative advantage for the industry, and therefore they point to industries that might be important exporters and sources of regional product, and low LQs suggest that these industries might be underrepresented in a region and hence their products might need to be imported, hence accounting for some negative entries in regional balance of payments. These speculations depend on a range of assumptions about industry mix, consumer tastes and preferences, and the like, so LQs are clearly only broad-brush indicators, but can be useful in pointing the analyst to industries that warrant further attention. Other methods discussed below will relax some of the assumptions that underpin LQ interpretations.

Related Measures of Concentration

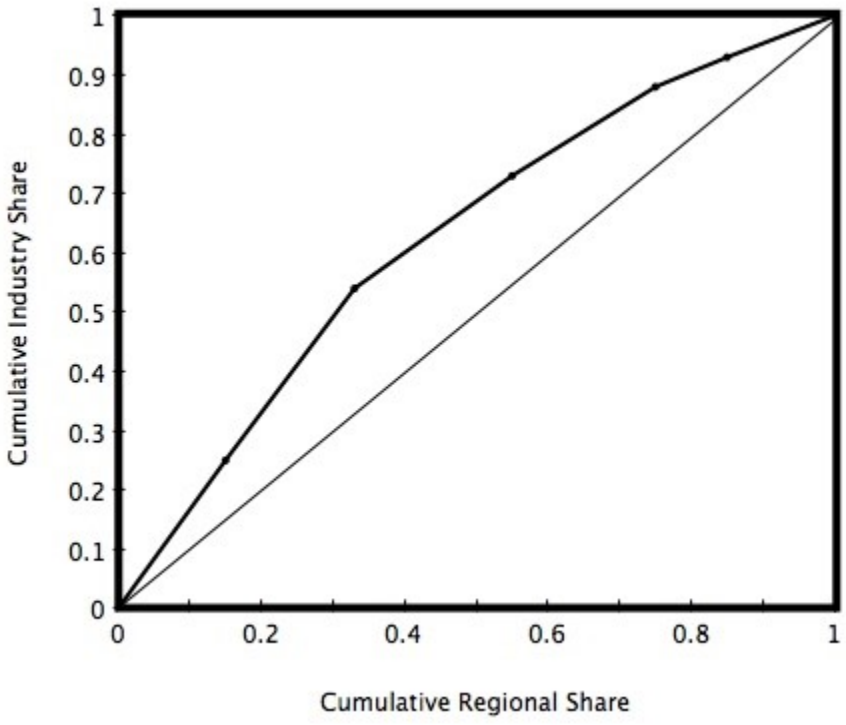
A related measure that focuses on a single industry's concentration across all regions is the Coefficient of Localization (CL). The CL relies not on the ratios of ratios, but instead is computed as one-half the sum of the absolute differences of between numerators and denominators in the LQ calculations for the industry in all regions. The closer this value is to unity, the more concentrated the industry is in the nation. An example for a fictitious industry and nation can be seen in the table below, where the LQ indicates that the industry is relatively concentrated in regions 4 and 5, and the value of the CL is 0.21. Industries with low CL might be less tied to specific regional attributes, and therefore might be good candidates for regional diversification in regions where the LQ is less than one. Diversification strategies will be discussed further, below.

	All Regions						
	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Total
A)Region's share of national industry employment	0.050	0.070	0.150	0.250	0.290	0.190	1
B) Regions share of national total employment	0.100	0.150	0.200	0.150	0.180	0.220	1
|A - B| * 0.5	0.025	0.040	0.025	0.050	0.055	0.015	0.21
LQ	0.500	0.467	0.750	1.667	1.611	0.864	

More formally, the CL equation can be written as

$$CL^R = .5 \sum \left| \frac{e_i}{e} - \frac{E_i}{E} \right| \qquad (2)$$

LQs and CLs also are related to Lorenz Curves, which graphically display the unevenness of distributions, and can be used to compare industry distributions by plotting more than one Lorenz curve on a single graph. To generate the Lorenz curve for an industry, regions are ranked by location quotient, and regional shares of national industry and national total employment are plotted on a cumulative basis, as shown below.[3] The slopes of straight-line segments are location quotients of regions. The ratio of the area between the curve and the diagonal line to the total area of the right triangle is another coefficient of localization. The closer this ratio is to 1.0, the more uneven is the distribution.



[3]When the order of industries is reversed, the Lernez Curve will lie below the diagnonal.

Industrial Diversity

Until relatively recently, industrial diversification was a dominant regional economic development strategy. The diversification strategy rests on the recognition that while a heavy concentration of employment in a single industry or set of closely related industries might carry some advantages, which will be discussed in the context of industrial clustering as a development strategy, it also carries with it a concentration of risk should the industry experience a downturn. By diversifying a regional economy, the region would be diversifying the risk of employment downturn in the same way as an investor guards against heavy losses by diversifying her stock portfolio. Diversification, then, would be expected to contribute to employment stability.

Despite the more recent emphasis on potential economies of industrial clusters and implications for more rapid growth, industrial diversity remains an important indicator of economic structure. Whereas the LQ and related concentration measures focus on individual industries, there is another set of measures that are used to quantify the degree of specialization or diversity of industry structure for all industries in a region. Among the most common regional industrial diversity indices are the National Average Index, the Herfindahl Index, and the Entropy Index. Each of these metrics provides a summary measure of the difference between a given region and its national economy in terms of industrial distributions. The implication is that the national economy itself is in some sense optimally diversified, hence these indices become normative. Of course, it would be possible to substitute any alternative industrial distribution for the national economy if there were rational economic reasons for doing so. These measures are also usually based on income or employment statistics, largely because these data are typically more readily available and reliable than estimates of output. However, any of these measures could be used.

Common Diversity Indices

Each of the industrial diversity indices rests on a normative assumption concerning the ideal regional industrial economic structure. Because the normative ideal can be expressed in a variety of ways, the measures differ accordingly. The national average index is among the earliest and simplest measures of regional industrial diversity. It emerged in the context of highly developed economies, where the national economy could be assumed to be diverse, and its structure taken as the norm. A perfectly diverse regional industrial structure would therefore mirror the national industrial structure, and departures from the national industrial concentrations reflect regional specializations, or departures from perfect diversity. When deviations are expressed in absolute value, the virtually identical to the coefficient of localization. When deviations are expressed as squared differences, the equation for the National Average index for region R is

$$NA^R = \sum \left(\frac{e_i}{e} - \frac{E_i}{E} \right)^2 \qquad (3)$$

A value of zero reflects perfect industrial diversification and larger departures from zero reflect greater regional industrial specialization.

A second regional industrial diversity index that has become increasingly popular in the related literature is the Herfindahl-Hirschman Index (HHI). This measure, which also is often used in studies of industrial organization and market power, is a function only of the region's own industrial structure, rather than a relationship to a reference region. The normative ideal in this

conceptual framework is equal shares of employment (or income or other industry size metric) in all industry sectors. A perfectly diverse region would thus have $1/N$ of its employment in each of its N industries. Departures from the normative $1/N$ share influence the HHI strongly, as the industrial shares are squared are summed, as shown in the formal equation below.

$$HHI^R = \sum_{i=l}^{N} \left(\frac{e_i}{e}\right)^2 \qquad (4)$$

The HHI value can vary from a minimum of $1/N$ to a maximum of 1.0. The maximum value would indicate that the region has only one industry.

A final index of diversity is derived from information theory and is known as the entropy index. The norm with the entropy measure is similar to that of the HHI, but this measure is sensitive to the number of different industries in a region, in that its maximum value increases as that number increases. The form of the expression most often use is referred to as Shannon's H, the formula for which is

$$H = -\sum_{i=1}^{N} \left(\frac{e_i}{e}\right) \ln\left(\frac{e_i}{e}\right) \qquad (5)$$

Shannon's H values range from 0 to $\ln N$. Because this measure is sensitive to numbers of industries, its value reflects not only the distribution of industry employment (or other relevant) shares, but also the numbers of industries that compose the different regional economic structures. This can be useful for monitoring intertemporal change, but for comparisons across regions, the value is often normalized by its maximum, to once again yield values that range from a minimum of $1/N$ to a maximum of 1.0. The normalized equation is

$$H^* = \frac{-\sum_{i=1}^{N} \left(\frac{e_i}{e}\right) \ln\left(\frac{e_i}{e}\right)}{\ln N} \qquad (6)$$

Although industrial diversity continues to be a mainstay of regional economic structural assessments, another side of the economic development coin focuses on the benefits of key industries, and clusters of similar and synergistic industries.

Key Industries

A prominent line of reasoning that can be traced growth pole/growth center theory revolves around the concept of key industries. Following work by Hirschman (1958) and Rasmussen (1956), whose measures were founded on input-output (IO) relationships among industries, key industries became the focus of a large literature. IO facilitates the identification of industries that exert greater than average influence on their economies by virtue of their forward (sales) and backward (purchases) linkages with other industries. Intermediate sales and purchases bind industries one to another and create interdependencies. Those that occupy the most prominent positions in multiple supply chains are identified as key industries. The absence of such industries in a region,

where these industries are deemed to be capable of operating economically, have become the basis for regional public agencies' efforts to attract these key industries.[4]

4.2 From Individual Key Sectors to Industrial Clusters

Many regions' policymakers have abandoned development policies focused on individual sectors (such as key sector strategy) in favor of a cluster-based approach. Rather than focusing on individual key sectors, this approach centers on the identification of clusters of industrial sectors with substantial mutual synergies based on mutual sales and purchases interdependencies (Feser and Bergman, 2000). These strategies, which rest on the theory of agglomeration economies, emphasize ways of promoting and supporting these clusters to facilitate and deepen their development. Bekele and Jackson (2006) have identified and discussed the most common approaches to industrial cluster identification.

Melding Clustering and Diversification Strategies

Despite the apparent contradictions between clusters and diversity, however, there has been increasing discussion of the coexistence – or at least creative perspectives on clustering and diversification. Jackson (2015) has provided an input-output based method for devising strategies that recognize comparative advantages in existing regional structures, quantify the strength of clusters already present, identify gaps and bottlenecks in cluster supply chains, explore the regional consequences of potential cluster diversification strategies that might serve to further diversify regional industrial structures. Outcomes from such strategies have been called diversified clusters. Jackson's cluster assessment diversification strategy (CADS) follows these general steps:

1. Use a single-sector method to select an industry or set of industries from a study region for consideration as the *anchor* industry or industries of one or more clusters,
2. Identify the current employment or output levels for these anchors,
3. Determine the industrial distribution of supporting, supply chain-linked industries that would be needed to fully support these anchors at existing production levels,
4. Assess the sufficiency of the anchor industry or industries for supporting the selected clusters by comparing existing production to supply-chain requirements, and
5. Evaluate the implications of diversifying into new specializations.

CADS provides a set of detailed instructions for implementing these steps, which "can identify existing strengths and gaps or bottlenecks in the regional economy – in terms of supply deficits; it can be used as a standard against which the existing distribution of industrial activity can be measured; and it can be used to identify the distributional implications of diversifying into new industry clusters, all of which will can lead to more rational economic development decisions" (Jackson, 2015, p. 123).

[4] For a recent review and discussion of key sector measures, see (Temurshoev and Oosterhaven, 2014).

4.3 Identifying Supra-Regional Trends

Nearly all of the metrics discussed thus far are founded on static concepts. As such, there is an unintended and potentially misleading implication that all industries are equally viable candidates for development, from both regional and supra-regional perspectives. This conclusion could lead a regional policymaker to work toward the recruitment or promotion of a targeted industry that simply might not be competitive in a given region. One broad brush approach that has allows the decomposition of changes in industrial structure into components that reflect national (supra-regional) trends, industry mix, and region-specific characteristics is called Shift-Share Analysis. This method has been in use for decades and owes its longevity to simplicity of implementation, interpretation, and extension.[5] Shift-Share Analysis has been used in a variety of policy contexts, including the identification of regional comparative advantages and other region-specific, relative strengths and weaknesses.

Shift-Share Analysis[6]

Once again, we use regional employment by industry as our indicator of industrial structure, although personal income or output data by industry would be equal informative when these data if and when these data are available. This method, however, requires industrial structure data for two different time periods. While there are numerous extensions, including dynamic shift-share (Barff and Knight, III, 1988) and the incorporation of spatial structure (Nazara and Hewings, 2004), the presentation below reflects the method in its most fundamental form.

With data for two different time periods, we use time $t-$l as a reference to the beginning period and time t to the ending period. Our industrial structure changes will thus refer to the period spanning time $t-$l to time t. Our variables are defined as follows:

e_t^r - total employment in region r at time t

$e_{i,t}^r$ - employment in region r industry i at time t

e_t^n - total national employment at time t

$e_{i,t}^n$ - national employment in industry i at time t

We first calculate the following three growth rates:

$$r_i = \frac{e_{i,t}^r}{e_{i,t-1}^r} = \text{growth rate for regional industry } i \qquad (7)$$

$$n_i = \frac{e_{i,t}^n}{e_{i,t-1}^n} = \text{growth rate for national industry } i \qquad (8)$$

$$n = \frac{e_t^n}{e_{t-1}^n} = \text{average national total growth rate} \qquad (9)$$

By definition:

$$e_{i,t}^r = e_{i,t-1}^r r_i = e_{i,t-1}^r \left(\frac{e_{i,t}^r}{e_{i,t-1}^r} \right) \qquad (10)$$

[5] More sophisticated methods called structural decomposition analyses have been developed using input-output accounts as empirical foundations. See Lahr and Dietzenbacher (2017) for details.

[6] This section draws heavily on Jackson and Haynes (2009), where various issues involved in selecting an appropriate time period for analysis, data development, and methodological extensions are addressed.

If regional industry i grew at the average national rate, its change over the time period would be

$$e^r_{i,t} = ne^r_{i,t-1} \qquad (11)$$

and the change in industry i in region r would be attributed solely to average national trends. However, if industry i is particularly fast or slow growing, there will be a difference between n and n_i. We can account for the deviation of a given industry from the national average using the following expression:

$$e^r_{i,t} = e^r_{i,t-1}[n + (n_i - n)] \qquad (12)$$

If the industry is fast-growing nationally, $e^r_{i,t}$ will be greater than the value obtained from equation (11), and it will be less than that value if it is growing more slowly than the nation.

If industry i grows at different rates in different regions, then there will be a non-zero difference between r_i and n_i . We can capture this effect with the following expression,

$$e^r_{i,t} = e^r_{i,t-1}[n + (n_i - n) + (r_i - n_i)] \qquad (13)$$

In which the bracketed term reduces to $r_i = \left(\frac{e^r_{i,t}}{e^r_{i,t-1}}\right)$, which duplicates the identity in equation (7).

The integrity of the accounting system that defines changes in regional employment by industry can be verified by subtracting $e^r_{i,t-1}$ from both sides, yielding

$$e^r_{i,t} - e^r_{i,t-1} = e^r_{i,t-1}[n + (n_i - n) + (r_i - n_i)] - e^r_{i,t-1} \qquad (14)$$

or

$$\Delta e^r_i = e^r_{i,t-1}[n + (n_i - n) + (r_i - n_i) - 1] \qquad (15)$$

and

$$\Delta e^r_i = e^r_{i,t-1}[(n-1) + (n_i - n) = (r_i - n_i)], \qquad (16)$$

where Δe^r_i is the study period change in regional industry i employment.

By separating the components of the right-hand-side of equation (16) we can identify the following values and interpretations:

The national share component $N_i = e^r_{i,t-1}(n-1)$, which is the growth in the regional industry that can be attributed to the national average rate of growth;

The industry mix component $M_i = e^r_{i,t-1}(n_i - n)$, which identifies the growth in the regional industry due to the difference between the specific industry's national growth rate and the national average rate of growth; and

The regional shift $R_i = e^r_{i,t-1}(r_i - n_i)$ regional industry i growth that cannot be attributed to industry or national effects. This regional shift component is often used as a measure regional comparative advantage for industry i .

Given these definitions,

$$\Delta e_i^r = N_i + M_i + R_i \tag{17}$$

Finally, we can sum both sides over all industries and show that

$$\sum \Delta e_i^r = \sum (N_i + M_i + R_i) \tag{18}$$

$$\Delta e^r = N + M + R \tag{19}$$

Shift-Share Analysis provides results for each industry that yield specific interpretations. Combinations of negative and positive values for the Mix and Regional Shift components characterize the industry's performance relative to the national average industry, and its performance in the region relative to its performance in other regions. These are summarized in the table, below.

M	RS	Interpretations
-	-	The industry was a poor performer nationally, and even poorer in the region than in the nation.
-	+	The industry was a poor performer nationally, but better in the region than in the nation.
+	-	The industry was a good performer nationally, but poorer in the region than in the nation.
+	+	The industry was a good performer nationally, and even better in the region than in the nation.

This summary information can be used to supplement and reinforce (+ +) or dampen (- -) regional enthusiasm for industries that other methods might identify as key industries or industry clustering targets.

4.4 Industrial Restructuring Challenges

Virtually all of the industry targeting and industrial restructuring methods must be considered in the context of local understanding and more comprehensive knowledge of the study region. These strategies can be complicated by a number of considerations, some of which are listed below.

1. Changes in firm ownership patterns can result in organizations of production that align more strongly with aspatial competitive advantages rather than with locational advantages. Some analysts have questioned whether geographical proximity is the major source of agglomeration economies.
2. Missing supply chain linkages might reflect the lack of a sufficient volume of demand to allow the activity to reach its minimum efficient scale, and hence, make that sector viable in the region.
3. Decreasing real transportation costs allow firms to search over wider geographies for inputs and markets.
4. Labor force skills and quality, physical infrastructure, and other industry-specific requirements must be sufficient to support targeted industries.

The ability of regional policy makers to effect significant change is in many cases constrained by national policy and global forces. Accordingly, attention is often directed to changes at the margin – enhancing a region's connectivity, investment in human capital and the provision of incentives or indirect support to enable local firms to upgrade technologically. Much less attention has been given to addressing the market failures that are in the scope of most regional and local governments, such as ensuring the fluidity of land markets or promoting a favorable business environment. The recent attention directed to the idea of smart specialization provides an example of an innovation in policy thinking that has been clearly motivated by the difficulties of measuring the contributions of past policy initiatives.

5 *Regional Accounts and IO Software*

Regional Accounts

Regional accounts are to regions what national accounts are to nations. These accounts provide the foundations for a wide array of analytical tools and techniques. The accounts detail the interactions among economic agents within the system and with other regions and the rest of the world. These economic agents are the establishments and firms that compose the production sector of the economy, and the consumers of the goods and services that they produce, which includes households, governments, investment, and trade. The establishments are grouped in industries, and their products are grouped into corresponding commodities.

Because region economic systems are typically more open than national counterparts, an accurate identification of which interactions take place within the region and which cross the regions borders – in the form of imports and exports – is critical for the generation of meaningful analyses using the suite of tools and techniques that are available. Analysts' initial challenge is often the acquisition or construction of regional accounts. This challenge is amplified by two factors. First, regional accounts constructed from primary data are rare. Most regional analysts must rely on one of several methods that can be applied to generate regional accounts from corresponding national accounts using a smaller set of region-specific data to estimate counterparts to national parameters. Second, whereas most of the tools that have been developed for national or regional input-output accounts operate on industry-by-industry (or interindustry) accounting frameworks, it is a reality of the data collection and reporting conventions that most nations publish accounts not in interindustry format, but in what is known as a supply-use framework. Interindustry accounts can be derived from supply-use data, but the necessary data manipulations are not always straightforward and intuitive.

As an aid to regional analysts, computer software applications have been developed primarily for the purpose of facilitating the construction of regional accounts. For example, IO-Snap, described further below, supports accounts generation and standard final demand impacts assessment, but more extensive analytical capabilities beyond multiplier analysis, descriptive economic statistics, and impacts assessment are still being added. While additional analytical features are under development, however, IO-Snap can be used to generate regional interindustry accounts that can then be exported for use with software applications like REAL I-O that provide a much more comprehensive suite of analytical tools. IO-Snap and REAL I-O are described briefly, below.

IO-Snap

IO-Snap, which stands for "Input-Output – State and National Analysis Program," is a Windows-based computer software program that was developed to facilitate the use of input-output data from U.S. national make and use tables. In the process of assembling the various utilities that support national and state-level input-output analysis, the developers also created an environment that facilitates inter-state comparisons of input-output related variables such as employment and worker compensation. Annual U.S. IO tables from the Bureau of Economic Analysis (BEA) for 1998 through the most recently published year are included with the software. In addition to default data covering the U.S. 50 states and the District of Columbia, user-supplied data in make-use format can be imported for other geographic areas.

Make and use tables contain a wealth of data in their original formats. Production functions and output distributions, and final demand activity supplemented by employment and compensation by industry data can be easily accessed and extracted for use in other applications. Using the default state-specific data or user-supplied data for other U.S. regions, users can generate regional input-output accounts. With the national, imported, or user-generated tables, users can create Industry by Industry, Industry by Commodity, and Commodity by Commodity direct and total requirements tables for a variety of supported applications. Final demands by commodity or by industry can be specified, and impacts assessments results can be produced. Standard results can be generated, including income and employment impacts, disaggregated and total multipliers. Cut and paste options are enabled throughout so that users can easily transfer data to spreadsheets or other analytical software for further analysis, graphing, etc.

Within IO-Snap, data can be edited and displayed in a variety of formats, compared and contrasted across geographical definitions at different times, and fundamental input-output based analyses can be implemented. Prior to generating the requirements tables, the user can modify use table columns (including final demand distributions) and make table rows. Available codes of table operations and analysis are outlined in the Annex. IO-Snap software is available from https://www.IO-Snap.com.

REAL I-O Software

REAL I-O, an input-output operation software is a generic toolbox of Input-Output (IO) analysis based on open-source architecture running on Windows XP/7. Following the previous versions, termed PyIO (Nazara and Hewings, 2004), Python is retained as the interface building software. However, the main modules of matrix calculations have been currently migrated to the R language environment (SPlus equivalent freeware). This change allows the users to introduce their own database and additional functions in a much more convenient way than in previous versions. The migration will continue over the next several months and should be complete by the end of August 2018.

At the moment, several analytical functions of intra and inter-regional input-output analysis are preloaded in the REAL I-O package. The available codes of table operations and analysis are listed in the Annex. The latest version of the REAL-IO software is available at http://www.real.illinois.edu/realio/. The example data sources (e.g., OECD STAN Input-Output Database for 44 countries and Inter-country inter-industry) are also included.

6 *Spatial Analysis of Regional Economies*

Regional economics offers a rich empirical setting for the application of geospatial methods, as our review of regional economic development research has highlighted a number of theoretical constructs that call out for empirical measurement. In this section, we outline a number of such methods, linking each to particular theoretical concepts and discuss their implementation and use in the analysis and monitoring of regional economic systems.

We begin with measures of inequality, polarization and concentration for a national system composed of interacting regional economies. Closely related to, but distinct from, polarization measures are measurements of spatial clustering, which include global measures of spatial autocorrelation. We provide an overview of so-called global measures of spatial autocorrelation as well as their combined use with measures of polarization. We then shift the spatial focus to discuss local measures of spatial association. These provide the ability to detect hot(cold)-spots of economic activity that might be responsible for the overall patterns detected by the global measures or spatial-outliers that depart from the global pattern.

The measures of polarization, clustering, and local spatial association are all focused on static patterns measured at one point in time. Recent work in spatial statistics and GIScience has focused on developing new methods that extend these to consider the dynamics of these patterns. Methods of exploratory space-time data analysis can be used to study questions of spatial income mobility that has to date been largely absent from the debates surrounding the regional equity-efficiency tradeoff. We close this section with an overview of recent developments of machine learning in GIScience which may offer new approaches to the study of regional economies.

6.1 Inequality, Lorenz Curves and Convergence

Inequality for a collection of R regions in a national system has been measured in a number of ways. The concept of σ -convergence Young et al. (2008) is perhaps one of the most widely employed, relying on the sample standard deviation:

$$s_t = \sqrt{\sum_{r=1}^{R} \frac{(y_{r,t} - \overline{y}_t)^2}{R-1}} \qquad (20)$$

where $y_{r,t}$ is income in region r at time period t and $\overline{y}_t = \sum_{r=1}^{R} y_{r,t}/R$. For comparative analyses, the coefficient of variation is sometimes employed:

$$cv_t = \frac{s_t}{\overline{y}_t} \qquad (21)$$

These measures of σ-convergence are scalar indicators that capture one aspect of the entire distribution of incomes across the R regions in the national system. Measures that are designed to consider more fully the distribution can be obtained by repurposing the Lorenz Curves and Gini coefficients, we previously encountered in the study of regional industrial structure, by replacing measures for different industries within a region with say per-capita incomes across the R regions (Frick and Goebel, 2008).

Polarization within the interregional system has been measured using regional adaptations of the Esteban and Ray (1994) index

$$p(\alpha)_t = \sum_{r}^{R} \sum_{q}^{R} s_{r,t}^{1+a} s_{q,t} |y_{r,t} - y_{q,t}| \tag{22}$$

where α is a parameter that expresses the sensitivity to polarization, and $s_{r,t}$ is the population share of region r (Ezcurra, 2009).

6.2 Spatial σ-convergence and Spatial Gini

The previous measures of inequality and dispersion are silent on the geographical arrangement of the regional economies. Put another way, in addition to the observed map consisting of R regions, there are a total of $R!$ map patterns that could be generated such that each map obtains the same values for the measure of inequality at hand. Because of the locational invariant property of traditional measures of inequality, several authors have suggested spatially explicit measures for σ convergence (Rey and Dev, 2006; Egger and Pfaffermayr, 2006). These allow for the partitioning of overall dispersion/inequality into a pure inequality component and spurious dispersion that arises from the complications due to spatial dependence. In the same spirit as spatial σ-convergence, Rey and Smith (2013) have suggested a spatial decomposition of the Gini coefficient which distinguishes between pairwise inequality for neighboring economies versus inequality between pairs of regions that are geographically distant from one another.

6.3 Theil Interregional Inequality Decomposition

$$T^t = \sum_{r=1}^{R} s_r^t \log(R s_r^t) \tag{23}$$

and:

$$s_r^t = y_r^t / \sum_{i=r}^{R} y_r^t \tag{24}$$

where R is the number of regions and y_r^t is per capita income in region r in period t.

Decomposition of total inequality is obtained as:

$$T^t = \sum_{g=1}^{\omega} s_g^t \log(n/n_g s_g^t) + \sum_{g=1}^{\omega} s_g^t \sum_{i \epsilon g} s_{i,g}^t \log(n_g s_{i,g}^t) \tag{25}$$

where n_g is the number of observations in group g (and $\sum_g n_g = n$), $s_g^t = \sum_{i \epsilon g} y_{i,g}^t / \sum_i^n y_i^t$ is the share of total income accounted for by group g, and $s_{i,g}^t = y_{i,g}^t / \sum_{i=1}^{n_g} y_{i,g}^t$ is region i's share of group g's income.

Regional applications of this decomposition are based on an exhaustive and mutually exclusive assignment of regional economies to groups. As a result, inequality is split into that due to average differences between regional groups (so called interregional inequality, the first term) and

inequality between regions belonging to the same group (intraregional inequality, the second term). Shorrocks and Wan (2005) summarize the literature finding that the interregional component is often smaller than the intraregional counterpart.

6.4 Exploratory Spatial Data Analysis

Recent developments in the field of exploratory spatial data analysis (ESDA) afford numerous opportunities that can be used to analyze interregional linkages. The exploratory nature of these measures implies that their role is to characterize spatial patterns in terms of departures from spatial randomness due to spatial clustering and or dispersion. By themselves, these methods are not intended to "explain" these patterns but are powerful diagnostics to detect spatial structure and suggest that spatial processes are at work. This exploratory stance is sometimes dismissed as "measurement without theory", however we feel that this critique is misplaced. Indeed as Rey and Le Gallo (2009) argue, ESDA methods can offer important complementarities to formal econometric modeling of regional economic systems. We see much potential for a more comprehensive analytical framework for regional economic analysis that integrates ESDA methods with economic process modeling including spatial econometric, computable general equilibrium models and interindustry modeling frameworks of input-output and social accounting

6.5 Global Autocorrelation Measures

Spatial autocorrelation is an articulation of Tobler's first law of geography: "Everything is related to everything else, but near things are more related than distant things" (Tobler, 1970). From an economic perspective, the presence of spatial autocorrelation can reflect the operation of many processes that link regions together. Labor migration, capital flows, trade networks, value chains, intergovernmental transfers and policy copy-catting are but a few of such processes that can give rise to spatial association.

It is important to note that autocorrelation and concentration, while similar, actually capture different characteristics of economic space. Concentration or polarization derives from the a-spatial attribute distribution - and speaks to the degree of modality. A high degree of modality would indicate that the attribute in question (say regional GDP) is concentrated in sets of regions but does not necessarily provide any further information about the spatially explicit nature of those sets of regions.

6.6 Local Autocorrelation Measures (Spatial Clusters/Hot-Cold-Spots)

The global measures of spatial autocorrelation provide what are referred to as "whole map" statistics. That is, they provide scalar measures of the extent to which the map pattern as a whole departs from the null hypothesis of spatial randomness. Important complements to the global measures are local indicators of spatial association (Anselin, 1995). These serve two main roles. As focal measures, the LISAs can be used to identify so called hot (cold) spots that may be driving the overall pattern of spatial association. For example, a map with strong positive global autocorrelation might reflect patterns of value-similarity in space (neighboring units having similar attribute values), while the LISA values for each region can be inspected to identify the relative importance of local units for contributing to the global pattern.

The second role for LISAs is to detect spatial outliers. These are local units that display association distinct from the overall pattern. For example, in the case of positive global spatial association, a local spatial outlier would reflect negative association with its own attribute value being inversely related to those of its neighbors. These locations could become the focus for subsequent investigation or targeting.

6.7 Markov and Spatial Markov/Distribution Dynamics

The measures of inequality and polarization reviewed above focus on a single cross-section of regional economies. The evolution of these measures can provide policy makers insights as to the effectiveness of policies designed to reduce regional disparities. Yet these measures are fairly aggregate in scope, informing on the external characteristics of regional income distributions such as whether polarization (modality) or dispersion (sigma convergence) are declining or worsening.

The rise of the distributional dynamics school of analysis can be seen in part as a response to this external focus, as well dissatisfaction with the overly restrictive nature of formal models of economic convergence (Fingleton, 1999). Distributional dynamics has introduced the concepts of discrete Markov chains (Quah et al., 1993) and stochastic kernels (Quah, 1996) to study the internal dynamics of regional income distributions. More specifically, these approaches can quantify the amount of internal mixing and churn in regional income distributions over time, as well as support measures of regional income mobility, a topic we return to below in more detail. Closely related to stochastic kernels is the application of stochastic dominance to study the evolution of regional income distributions over time (Carrington, 2006).

Stochastic kernels and discrete Markov chains have seen widespread application in the regional economics literature, following their use in international comparative studies. However, their application at the regional scale had largely ignored the empirical regularities of regional income series, namely strong levels of spatial dependence and/or spatial heterogeneity. Several extensions of the traditional Markov framework have been suggested to incorporate spatial dependence. The spatial Markov framework (Rey, 2001; Rey et al., 2016) allows for the transitional dynamics (i.e., the probability of a region moving up or down the regional income distribution) to be related to the levels of income found in its neighboring regions. Application of spatial Markov methods has uncovered widespread evidence of spatial poverty traps and growth magnets (Le Gallo and Ertur, 2003; Mossi et al., 2003; Bosker, 2007; Bosker and Krugell, 2008; Villaverde and Maza, 2012).

The Markov paradigm has also provided a mechanism to move the cross-sectional measures of spatial autocorrelation into a dynamic frame. By embedding the quadrants of a Moran scatterplot (HH, LH, LL, HL) as states in a Markov chain, a LISA Markov can be developed which affords a rich taxonomy of space-time transitions (Rey and Janikas, 2006). The following table reports results from application of the LISA Markov to 32 Mexican states over the period 1940-2000. The transition matrix is diagonally dominant, with the HH and LL states displaying the strongest staying probabilities. In the long run, this is estimated to result in a strengthening of spatial clustering as the ergodic distribution accumulates more mass in these two states.

k	HH	LH	LL	HL
HH	**0.897**	0.051	0.026	0.026
LH	0.115	**0.577**	0.231	0.077
LL	0.000	0.078	**0.833**	0.089
HL	0.108	0.081	0.135	**0.676**
Ergodic Distribution	0.326	0.139	0.373	0.161

6.8 Mobility

Although regional inequality and growth have commanded the vast majority of attention in the regional science literature, the concept of economic mobility has recently begun to draw focus. Regional scientists are borrowing from the literature on intergenerational income mobility (Maasoumi, 1998) where the focus is on the upward or downward movement of individuals in an income distribution relative to the position of their parents. A spatial turn to the notion of income mobility replaces the life-time earnings of parents and their offspring with regions at different moments of time and considers how regions may, or may not, change position in the regional income distribution. As mentioned above, the Markov framework can be used to provide aggregate measures of spatial income mobility. More recently, there have been a number of new measures of spatial income mobility employing concepts of rank concordance and circular statistics (Hammond and Thompson, 2002; Rey et al., 2011; Rey, 2014, 2016).

6.9 Integrating equity, efficiency and mobility

There is a need to revisit the debate surrounding regional inequality and national growth (efficiency) to introduce mobility (Moser and Schnetzer, 2017; Rey, 2018). It is generally acknowledged that studying inequality or national growth separately provides only a limited understanding of either phenomena. The same argument holds for the concept of regional income mobility. For example, estimating the rate of spatial income mobility, while important may fail to address broader questions about the role of that mobility in interregional welfare. In the intergenerational literature, much attention has been placed on the question as to whether mobility is equalizing in long run incomes (Fields, 2010). We currently do not know whether regional income mobility works to reduce regional disparities, nor do we know the relationship between national economic growth and spatial income mobility. This tri-variate relationship will require new models and frameworks but offers the potential for a more holistic understanding of regional development., ,

6.10 Spatial Counterfactuals

Counterfactuals provide a way to disentangle the role of changes in attributes and the changes in model parameters as drivers of distributional change. (Fingleton and Palombi, 2013; Carrillo and Rothbaum, 2016). Originally used in the analysis of gender discrimination in the labor market, the approach relies on the construction of two different conditional wage distributions. The first is estimated for female participants in the labor market where the wage distribution is conditioned on observed years of schooling and experience. In a similar fashion, a conditional distribution is also estimated for male participants. A counterfactual distribution is then estimated for females

reflecting the conditional wage distribution that would obtain given their distribution of experience and schooling and the returns to these characteristics for male labor market participants.

Carrillo and Rothbaum (2016) have turned a spatial lens on this approach in the context of modeling urban residential location choices. The approach first estimates conditional distributions for the residential location of Hispanics in Washington D.C. subject to observed individual characteristics including age, education, and gender. With this conditional distribution in hand, the change in the actual distribution of residential locations of Hispanics over an interval is decomposed into components due to changes in the "returns" to these characteristics in influencing locational choice, and changes in the characteristics themselves over the two periods. This is accomplished through the creation of the counterfactual distribution for residential locations in the second period assuming that the returns to individual characteristics remained the same as in the first period, while allowing for the individual characteristics to change.

6.11 Machine Learning and Big Data

Use of machine learning methods has begun to appear in the regional economics literature. One of the earliest applications involved the use of regression trees to identify convergence clubs (Durlauf et al., 2005). That paper is important for signaling a change in the receptiveness of economists to the use of data instigated approaches to economic analysis. Previously dismissed as "measurement without theory", these new machine learning methods are increasingly seen as being novel approaches to uncover empirical patterns that have been previously unrecognized. These new patterns, in turn, provide the basis for more flexible process-based modeling of regional economic growth, and the fusion of machine learning approaches with econometric models offers new avenues to address questions surrounding model stability and process heterogeneity.

Alongside the adoption of machine learning methods, has been a recognition of the potential for new types of data sources to advance the study of regional economic development. Drawing on the big data revolution, economists have begun to tap into new forms of data that are now becoming available at spatial extents, scales, and temporal frequencies that were previously beyond reach. A prominent example is the use of remote sensing imagery and pattern recognition algorithms to provide scalable analyses of regional growth (Lessmann and Seidel, 2017). The question of the inverted-U relationship between the level of spatial inequality in a country and the country's level of economic development is revisited through an expanded cross-section of regions made possible using remote sensing data on night-time lights. The approach is to first estimate a model relating regional incomes to luminosity for countries with established regional accounts. This relationship is then employed to generate estimates for income in regions in developing countries where regional accounts are unavailable or of low quality, yet remote sensing data are available. This substantially expands the empirical basis for the inequality-development analysis since the traditional sample bias that had limited the analysis to more developed economies with official regional accounts is now removed.

7 *Conclusion*

As policy makers move forward in their efforts to improve living conditions and economic growth across regions of a country, acknowledging and understating that the mechanisms through which regional economic growth can be achieved differ from those that lead to national growth.

Researchers and policy analyses that seek to such policies must consider that assumptions of traditional neoclassical growth models pose serious constraints for the analysis of regional economies. For regions, interregional factor endowments, and differences in levels of factor productivity, may account for the advantage or constraints faced by an area compared to the rest of the country, or the world.

We have provided here a motivation as to why different methods are needed to understand the challenges of regions. It then follows to review some of the methods available to understand and assess the challenges regions face. While this review is not comprehensive, it provides the reader a set of tools that can be used to better understand the works of regional economies. These tools can be used to better asses needs of regions and carefully determine the possible impact of policies. We have identified several avenues to improve our understanding of regional economies. First, a better understanding of the economic structure of local economies is key for policy design. The layout of the interindustry and inter-regional industrial structure and trade relationships play a critical role in determining the effects of various policies and programs. Second, a complete description of regional economic structure begins with an inventory of employment, compensation (wages and salaries), and output by industry. This will deepen the understanding of how specialized or diversified is the regional economy, what are its comparative and absolute advantages, it will facilitate the development of behavioral models for assessing impacts of policies, and it will increase the understanding of inter-regional linkages. Regional accounting systems appear as a fourth tool that can contribute to the accurate identification of interactions that take place both within the region and those that cross the regions borders – in the form of imports and exports. Finally, the spatial dimension of regional analysis can leverage the use of geospatial information and bring additional information to discussions such as inequality or conflict that often are engrained in spatially confined areas but for which the spatial dimension is often ignored in economic analysis.

While most of these methods have been widely applied in the developed world, more work is needed in developing countries to understand how regional economies work and how methodologies applicable in developed countries fare when used to analyze developing countries' challenges. A lack of data has long been an important constraint in the developing world, but new data sources promise to address this gap.

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Annex

IO-Snap Software

The organization of the IO-Snap menu structure is presented below as a description of IO-Snap functionality. Starred (*) items open additional user input forms.

- File
  - Load Data*
  - Save Data*
  - Excel* under development
  - Print*
  - Preferences*
  - Program Reset
  - Exit
- Data
  - IO Accounts*
  - State Industry Data
    - ⋆ By Region*
    - ⋆ Compensation Rates (All Regions)
    - ⋆ Employment (All Regions)
    - ⋆ Gross Industrial Product (All Regions)
    - ⋆ FTE-Job Ratios
  - Gross Domestic Product
  - Requirements Tables*
  - Multipliers*
  - Sector Distributions
    - ⋆ Industry Accounts
    - ⋆ Commodity Accounts
    - ⋆ Industry Labor
    - ⋆ Commodity Trade Balance
  - Edit
    - ⋆ Aggregation*
    - ⋆ Modify Data

        - ◇ Use*
        - ◇ Make*
        - ◇ Final Demand*
- Analyze
    - Regionalize*
    - Impacts*
        - ⋆ Type 1 Industry-Driven*
        - ⋆ Type 2 Industry-Driven*
        - ⋆ Type 1 Commodity-Driven*
        - ⋆ Type 2 Commodity-Driven*
- Help
    - About
    - Documentation
    - Activate*
    - Deactivate*

REAL-IO Software

The available REAL-IO operations and analyses are organized as follows:

Table operations

Displaying I-O tables

- Displaying industrial structure of target regions by value-added and Output

Single region (country) analysis

- Import penetration ratio
- Key sector analysis
    - Leontief inverse (using purchase coefficients)/ Backward linkages
    - Goshian inverse (using sales coefficient)/ Forward linkages
- Import content shares of exports
    - Estimates the leakage through import when export activity increase
- Induced value-added by exports
    - Estimates the additional value added generated by increased export activities
- Labor multipliers

    - Estimate the indirect and induced effects of direct changes in labor by sector
- Field of influence
    - Estimates the economy-wide impact of change in individual, multiple, row or column coefficients
- Average propagation link
    - Estimates the rounds of spending generated by an expansion in each sector
- RAS procedure to update tables
    - Provides a method to update input-output tables given information on the margins for a future year

Multi region (country) analysis

- Interregional spillover effects
    - Estimates the spillover effects from changes in one region or sector
- Average propagation link of multiregional framework
    - Estimates the rounds of spending generated by expansion in one sector in one region

Under Development

- Feedback loop analysis
    - Decomposes the structure of interdependence between sectors into a hierarchical system of loops
- Structural decomposition analysis
    - Decomposes change in an economy into contributions by technology demand and their interactions
- Hypothetical extraction
    - Explores the impacts of the removal of a sector (single economy) or a region (multiregional system) on macro measures (output, income, employment)