A reconnaissance through the history of shift-share analysis

Citation to Publisher Version: Lahr, Michael L. & Ferreira, João Pedro. (2020). A reconnaissance through the history of shift-share analysis. In P. Batey (Eds.), *Handbook of Regional Science* New York City: Springer.

Citation to *this* Version: Lahr, Michael L. & Ferreira, João Pedro. (2020). A reconnaissance through the history of shift-share analysis. In P. Batey (Eds.), *Handbook of Regional Science* New York City: Springer. Retrieved from http://dx.doi.org/doi:10.7282/t3-0gs3-nw29.

A Reconnaissance through the History of Shift-Share Analysis

Michael L. Lahr[*] and **João Pedro Ferreira**[+]

ABSTRACT. Some research methods come and go, and others persist through time. If you had asked regional analysts in 1980 about the future of shift-share analysis, most of them undoubtedly would have grunted in dismal tones. Statistical software and ever-rising computational capacity appeared to be storm clouds on the horizon for this analytical approach that had no apparent theory to support it. But now, almost 30 years later, we find the shirt-share is "still alive and well,"[1] in fact perhaps in greater use than ever before, seemingly due in part to the intensive worldwide proliferation of electronic spreadsheets, some even pocket-ready. This paper takes the reader on a reconnaisance of the literature that attempts to explain how shift-share has managed the hazards of time, the cloaks it presently dons, and possible avenues in which researchers may wish to direct its future development.

1. Introduction

Shift-share analysis (SSA) derives from the perspective that a region "develops because the nation, of which it is a part, develops" (Isard, 1960: 545). The method's long-run success undoubtedly stems from "the fact that the statistical information required is very elementary and the analytical possibilities that it offers are quite large" (Esteban-Marquillas, 1972: 249). But this analytical tool continues to be taught and used, despite a large number of detractors over time. That is, it still plays an important role in regional planning and analysis.

Fortunately for the authors of this piece, SSA has a rich history often grounded in fascinating debates about the mathematics of its components and the economic meaning of them. Early on, some of these debates got rather intense, occasionally resulting in new proposals and extensions to the approach. We detail the most important pieces herein. Even though some of the approaches presented herein were wrong-headed and eventually abandoned. SSA's ready application undoubtedly engaged a wide range of users and spectators. Most of this occurred when both collecting and collating data and then applying analytical tools to them was far less easy than it is today. Nowadays SSA is adopted within much more sophisticated frameworks. At the same time, tools inspired by shift-share, like structural decomposition analysis, have largely increased popularity of the general approach due to the growing availability of data.

---

*[*] Edward J Bloustein School of Planning and Public Policy, Rutgers, the State University of New Jersey, lahr@rutgers.edu.

+[+] Edward J Bloustein School of Planning and Public Policy, Rutgers, the State University of New Jersey; and Govcopp, University of Aveiro, Portugal.

1 Apologies to Rick Derringer, who wrote a song of this title in 1973, and Johnny Winter whose band made that song popular.

We ask the reader to be understanding. This is no full-blown compendium that reviews all works with shift-share content. Such a review would be overly lengthy and nigh unto impossible since at the date of writing this article a single original piece alone (Dunn, 1960) has been cited by nearly 800 published articles. Instead, we present a retrospective reconnaissance through what we contend is the salient literature. That is, we gloss over several papers that may have seemed important at certain junctures in time. Moreover, we do all we can to limit the density of equations and resort instead to plain language to discuss the various historical contributions (pointing to the key resources if readers want the mathematical detail). We do this in part to minimize reader pain, but also simply because placing the various equations in uniform notation would be tedious and overly time-consuming. In this vein, certain readers may wish to turn to overviews by Stevens and Moore (1980), Dinc et al. (1998), Loveridge and Selting (1998), Knudsen (2000), Mulligan and Molin (2004), and Haynes and Parajuli (2014, 2015).

2. **Shift-share early developments**

Shift-share analysis (SSA) began as a rough way to identify possible components of change in a regional setting. Hall and Tewdwr-Jones (2011) appear to suggest that SSA may have been first used in the so-called "Barlow Report" and Lamarche, Srinath, and Ray (2003) confirm it. The analytical work in this foundational document to British urban and regional planning was apparently undertaken by J. Harry Jones (1940a, 1940b). In it, he discussed the "structural effect" of overall industrial growth, which shows the degree to which growth in various areas of Great Britain could be postulated from the area's industry mix and national growth rates of those industries. Nonetheless, Daniel Creamer (1943: 85) appears to have been the prime spark of academic work after publication of his description the "measurement, industry by industry, of the divergence of the trend of employment in individual States from of the Nation as a whole". He calls a "locational shift" an event that "occurs when changes in the employment in a given industry in a particular State differs in degree from the change in the same industry on a national basis" (Creamer, 1943: 87). Regional analysts use this concept today.

While the above contributions were devoid of equations, later early work further detailed the approach. The main SSA equation includes variables (or components) that proximate explanations of how the employment evolves over a specified period for a specific industry in a specific region. That is, it is an attempt to explain employment of industry i in region R and in the period *t* () via the region's "national share" of employment over time, the region's divergence from the national "industry mix" over time—the "regional or locational shift," and the rest is the specialized drift for the region in industry *i*.

(1)

"National shift" (NS) in Equation (2) measures industry *i* employment in R as if it had changed at the same pace as total national employment. Here, are national employment at times 0 and *t*, respectively, and is region R's total employment at time 0.

(2)

Equation (3) represents the "industry share" (IS) of the national shift. That is, it adjusts for industry-specific growth at the national level, but respects region R's difference from the nation with respect to industry mix (industry shares). The industry differences in national growth from overall national employment growth are therefore identified via this component.

(3)

A positive *IS* identifies that particular national industry prospered compared to the national average. A negative-valued *IS* means that industry *i* failed to keep pace with other industries nationwide.

Finally, Equation (4) shows the industry-specific regional drift of *i* in R. It measures how much R's employment in industry *i* differs from expectations derived from national growth. Dunn (1960) called it the "differential shift" and later the region's "competitiveness effect" since it shows how the region's industry gained or lost share vis-à-vis the nation's.[2]

(4)

Table 1: Traditional representation of SSA

	0		*t*		Δ		%	
	R	Nation	R	Nation	R	Nation	R	Nation
Industry 1	400	800	450	920	50	120	13%	15%

2 Zelinsky (1958) classifies the evolution of industries estimated through the "regional shift" as a "decentralization" or "centralization" effect.

Industry 2	200	500	175	400	-25	-100	-13%	-20%
Industry 3	75	700	70	800	-5	100	-7%	14%
TOTAL	675	2000	695	2120	20	120	3%	6%

	NS	IS	ε	
Industry 1	24.0	36	-10.0	50.0
Industry 2	12.0	-52	15.0	-25.0
Industry 3	4.5	6.2	-15.7	-5.0

Table 1 exemplifies SSA using highly aggregated data for a hypothetical region. It shows that industry 1 and industry 3 have negative regional drift components (ε) while industry 2's is positive. The implications of these components and the extent to which local policy can affect changes in it has been the subject of some debate among planners and regional scientists. We see from Table 1 that industries 1 and 3 grew over period *t* , but their regional drifts (ε) were negative. So, despite growing, these two industries did not grow as fast as national trends suggested. They essentially lost market share to other states; i.e., they lost some of the competitive advantage that they had within the state. Industry 2 displays a somewhat opposite trend. Its presence declined within the state () but its regional drift is positive (ε=15). That is despite losing jobs, industry 2 did not hemorrhage industry 2 jobs as rapidly as the nation did; this region gained market share from other states, albeit in an industry that the nation itself may be losing markets share at an international scale.

The above is the traditional version. And there are rather simple variants of it. Unlike the location quotient (LQ), the base areal unit against which the local region is compared need only include the local region as a subcomponent.[3] That is, while we have suggested it is the nation above, it could be a state, province, metropolitan area, of some other meta-region of which the target region is a subportion.

3 Recall the LQ is defined as the region's share of arbitrary industry *i*'s employment divided by the nation's employment share of that same industry. It thus can be viewed as *i*'s supply/demand ratio since the denominator identifies the expectation of supply if all subregion's produced equal shares, given their economic size and assuming equal productivity. To view the denominator as the expected supply (or alternatively the region's demand), the meta-region The one with shares indicated in the denominator) would need to very nearly satisfies the condition that supply defines demand. This condition tends to be best met only at the area level defined by a nation.

In addition, there is no compelling reason to use employment by industry as the target regional measure. Very early on, both Zelinski (1958) and Fuchs (1959), for example, examined the evolution of U.S. value added by industry instead of employment, as "it reflects the participation of men and machines in the transformation of matter and the creation of utility". (Fuchs, 1959: 4).

Immediate subsequent methodological developments consisted of identifying an appropriate start date for the comparisons, including analyses of the possible differences that arise from choosing different time intervals. Indeed, Fuchs (1959) suggested using an intermediate date as a basis for comparison. Dunn (1960) noted the choice of time interval can obscure important distortions. Matilla (1964) unconvincingly argued that the reference year does not matter nearly so much as the temporal consistency of all components examined. Nonetheless, it is clear that such consistency is critical to the easy economic interpretation of findings.

Dunn (1960) suggested it could help analysts to split industry-based findings into inward shifts (those that are positive) and outward shifts (those that are negative).[4] He contended that this approach helps to better understand the target region's relative competitiveness.[5] Dunn (1960) noted that, as in the case of selecting the time interval for the analysis, the level of aggregation selected for industry analysis can obscure heterogeneity.

Clearly, SSA was gaining some traction, despite some debate about its promise as a research tool. Ready application and accessibility were in its favor. Recall, time-series regression forecasting models were not yet a twinkle in Norman Glickman's[6] eye since they were just becoming frequently used at the national and international levels. In this vein, Ashby (1964) pointed out SSA's ability to help understand future convergence and divergence across industries located in different spatial components of the same meta-region. Houston (1967: 579) was more

---

4 Stevens and Moore (1980: 422) affirm that Dunn "appears to be concentrated on overall regional economic performance rather than on the relative growth or decline of individual industries". In other words, they believe that Dunn could have underlined SSA's importance as means of examining changes in regional comparative advantage, rather than just suggesting it provides a detailed analysis by sector.

5 As an example, in Table 1, industry 3 would concentrate 61% of outward shifting and industry 1 would have 39%. Complementarily, industry 2 would have 100% of the net inward shifts.

6 Norman J. Glickman wrote his dissertation *Econometric Analysis of Regional Systems* in 1969 under F. Gerald Adams and Lawrence R. Klein at the University of Pennsylvania. It is widely recognized as the first fully articulated subnational macroeconometric model.

skeptical, contesting the notion that "industries in a region should grow at the aggregate national". So Ashby (1968) clarified, arguing that SSA cannot yield an explanation of behavioral growth; rather, it simply compares the performances of regions' economic growth as contrasted against a common reference set. Nevertheless, researchers seemed to agree that if shift-share was not a forecasting tool at this point, it seemed likely that just a few tweaks by some smart future researcher could make it one.

So, primordial SSA existed at the start of the 1960s. National share, industry shifts and regional drift could now be combined to yield better understand the evolution of an industry located in a given region of a certain country. But could SSA could become the forecasting tool the regional science community was seeking? The jury was out debating this issue during the following decade; it contributed to a number of improvements in the SSA.

3. **SSA as a forecasting tool**

Work in the late 1960s and early 1970s pushed SSA toward becoming a more accurate and popular forecasting tool. Stilwell (1969) focused on the industry mix component, identifying it as the main proximate cause of industrial growth in most of the regions in his work.[7] That is, regions with a positive change in their employment tended to have employment concentrated in industries that grew rapidly nationally. Brown (1971, 1973) confirmed this finding and further asserted that the regional drift component suffers great instability, disabling analysts' abilities to predict it. In this vein, Brown set the first nail in the coffin for SSA as a forecasting tool in concluding that forecasts derived from it would necessarily be uncertain and, hence, risky to rely upon. But Paraskevopoulos (1971) kept the window open a crack by noting Brown (1971) may have violated Dunn's (1960) point about identifying the proper period to which SSA ought to be applied, so that his could not be the final words on the matter…at least not with a reasonable degree of certainty.

Floyd and Sirmans (1973) suggested that there was no reason to believe that the regional drift component should be stable over time, so they focused on other variables as possibilities. They noted that regional growth rates by industry tend to converge toward the nation's over time. Analysts pounced on this notion immediately with the thought it could improve SSA predictive

7 Ashby (1970), however, argued that Stillwell equations for industry mix violated Matilla's (1964) conjecture about the temporal consistency of the components.

capacity. It should be noted that this idea had been advanced as early as Miller (1971) who also found some diverging regions. He rationalized that such instances might have been due to input and labor costs that surged from the over-concentration of an industry or industries in given region.

James and Hughes (1973) contrasted SSA findings against those of a constant share model. Following Miller (1971), they suggested that regional drift should be expected to decelerate, even become negative, as a region becomes specialized to the extreme in a given industry. It is not clear whether this expectation was due to input and labor shortages or to sudden declines in returns form agglomeration economies. Regardless, they note that positive regional drifts are unsustainable when they are persistent and become ever higher for more than a couple of decades. The implications of this are that, theoretically, SSA could be a reasonable short-run forecasting tool most of the time in most regions. But it is unlikely to work well where the degree of industry specialization is very high or where a given industry is practically absent. Borts and Stein (1964) had come to similar conclusions simply based on location economic theoretic grounds. They noted that positive regional drift is based on specific locational advantages, which fade as prices of land, labor, capital or other inputs start to increase. In other words, a region's degree of industry specialization is never infinitely elastic. Nonetheless, Paraskevopoulos (1971, 1974), Kuehn (1971) and Floyd (1973) began to present evidence that the regional drift component was, in the main, fairly consistent over time.

Finally, in their review of SSA work, Stevens and Moore (1980) conclude that "it is hard to justify either a constant shift or a constant share assumption on theoretical grounds". And so, along with the advent of Glickman's (1977) publication of his dissertation on econometric forecasting model of Philadelphia, the search for a way to make shift-share a forecasting tool was basically abandoned.

4. **Finding meaning in the drift component**

SSA's simplicity and the insight it provided kept it in the limelight insofar as planners and regional science practitioners were concerned. Its use continued with hopeful advances in its formulation and form. This work often proved to be worthwhile. In part this is because Stevens and Moore's (1980) review enabled a better understanding of shift-share fundamentals, and in so doing it identified some clear avenues for future work. One avenue was that much more had to be done if SSA could ever be a forecasting tool. Another was that some statistical assessments should be done with respect to the relation between regional drift and some set of locational socio-economic and demographic variables. Their hope was that it might ground SSA in the theories of regional growth and development (e.g. agglomeration forces and market orientation). But a main Stevens and Moore point was that improvements to SSA should be possible and welcomed.

Taking this as a cue, authors started to focus on the proper set of independent variables to be included in a right and proper SSA equation. A foundational critique had been formulated some years before by Rosenfeld (1959) who postulated that regional drift depended on the region's industry mix. In essence, Rosenfeld stated that a given share of national growth of a specific industry in two different regions should result in a different regional drift due to the different industrial endowments at the outset of the period of analysis. This was a profound thought at the time that was largely ignored, perhaps because it was only accessed by francophones. It suggested that no one had yet properly identified what the regional drift component was in socio-economic terms. Ultimately Rosenfeld, perhaps unknowingly, was suggesting if the regional drift of a given sector in fact displays any special dynamism, that dynamism is influenced by the magnitude of that industry's connections with other industries within the region.

Table 2: Example of a type of Rosenfeld critique to the SSA

	0			*t*			%		
	Region A	Region B	Nation	Region A	Region B	Nation	Region A	Region B	Nation
Industry 1	200	500	1200	250	625	1375	25%	25%	15%
TOTAL	1000	1000	2500	1050	1125	2675	5%	13%	7%

	National Share		Industry Mix		Regional Shift	
	Region A	Region B	Region A	Region B	Region A	Region B
Industry 1	14.0	35.0	15.2	37.9	20.8	52.1

We use Table 2 to demonstrate Rosenfeld argument. In both region A and region B industry 1 increases by 25% between time 0 and *t*. The two regions have the same total employment (1,000 jobs). The national change in employment of industry 1 affects both regions equally. But regional data reveal that the regional drift is higher in B than in A. The only thing that is different between both regions is the greater concentration of employment in industry 1 (and, of course, less concentration in all other industries). So, the regional drift either must measure some sort of special dynamism (1) between industry 1 and the industries within a given region, (2) just among the other industries, or (3) it is capricious/random.

Esteban-Marquillas (1972) suggested controlling for base-period homothetic employment (HE)—the number of jobs in a given region if the region had the nation's industry mix— hoping to distill something meaningful from the regional drift component.

=

Stokes (1974), discovered Esteban-Marquillas's decomposition lacked aggregation-disaggregation symmetry, i.e., its shift-share components of all sub-regions failed to sum to that of the meta-region. This sort of symmetry guarantees that SSA results do not depend on the level of spatial or sectoral aggregation that is applied. Extolling its merits, Herzog and Olsen (1977) believed homothetic employment could ameliorate somewhat the problem of measuring interindustry effects that are implicit in the regional drift component. They suspected that Esteban-Marquillas's (1972) allocation effect improperly weighted the industry mix, a problem identified as early as Fuchs (1959) and Matilla (1964). Akin to Laspeyres and Paasche indices, it appears SSA is extremely sensitive to whether industry mix is measured at the beginning or the end of the study period.

Arcellus (1984: 6) subsequently pointed out that "growing regions are expected to affect the employment levels of the industries in their midst in ways different than stagnant or backward regions do". So by using HE, Arcellus similarly decomposed the regional drift component that at least satisfied the property of aggregation-disaggregation symmetry (Haynes and Machunda, 1987). But even Arcellus himself had trouble deciphering the decomposition. Ultimately, Keil (1992) and Loveridge and Selting (1998) identified empirical shortcomings of the homothetic concept, so it was subsequently abandoned.

5. **Limits of time and dynamic SSA**

Perhaps some of the most meaningful improvements pertain to the time dimension of SSA. Thirwall's (1967) suggested sub-division of SSA into two or more sub-periods across a pre-specified time interval. For example, using the national business cycle, it might be worthwhile to follow trends from trough to peak and from peak to trough. Of course, regions often have business cycles that are distinct from the nation's (or other meta-region), so those also could be analyzed separately. Perhaps as a consequence of what seemed to be almost senseless slicing and dicing of time, Barff and Knight III (1988) suggested estimating SSA on an annual basis. So called "dynamic shift-share" readily enables unusual pairings of years and economic transitions. Shi and Yang (2008) suggest that this dynamic approach is particularly well suited for longer study timeframes, especially when dealing with small regions or in the presence of large shifts in local industrial mix. For example, Markusen et al. (1991) use this approach to its fullest to track the sensitivity of regional growth to international commodity flows. That is, they decompose value-added changes into import, export, and domestic market segments and a productivity component.

6. **The nation need not be the referent area**

Sihag and McDonough (1989) extended the meta-region from the nation to the world, arguing that magnitude of international trade demanded study at a global scale. While not necessarily embracing those thoughts fully, Loveridge and Selting (1998) noted that the same model could be applied to compare a region's performance with intermediate levels of spatial disaggregation, for example, at the census region, state, or county level if the target area is a municipality. Indeed, if one is working on a region that is a county or smaller areal level, a state or provincial comparison probably should be applied *in addition to* a national or global perspective. After all, policy tools are effected at that level of governance as well and presumably planning agencies at the local level have some voice in policy actions implemented by their meta-regions. In the end, we agree with Mulligan and Molin (2004: 115) that selecting the most appropriate referent region, "which is often but not always some larger region like the nation, is not an entirely straightforward task."

Through experience with spatial statistics and spatial econometrics via Cliff and Ord (1981), Anselin (1988), and predecessors, Dinc et al. (1998) recognized that spatial dependencies are undoubtedly inherent to the regional drift components. Nazara and Hewings (2004) and Mayor et al. (2005) understood that SSA's regional drift is unlikely to be spatially independent. That is, the structure and performance of surrounding regions undoubtedly influence the evolution of a given industry in a particular region. Nazara and Hewings's therefore use a spatially weighted version of characteristics of the region's neighbors as a proxy referent region. Rather than measure the national industry shift effect, they measure the difference between growth rates of a spatially weighted industries of immediately contiguous region's and those of the same industries for the nation; and a new/different regional drift component is then generated from the difference between the same spatially weighted neighbors measure and the local industry's growth. Many works followed using similar approaches with different sorts of spatial weights matrices (queen contiguity, rook contiguity, distance, travel time, etc.) as elaborated in prior statistical work by Klaasen and Paelinck (1972). Cheng (2011) notes that the regional drift components of such spatially dependent SSA can vary considerably depending upon the spatial perspective taken. In essence, the nature of the referent region and, in the case of spatial dependence, the spatial weights matrix used can make quite a substantive difference in SSA findings for a specific region. Of course, some degree of policy relevance to the target region should attach to the referent region as well.

7. The problem of productivity differentials

By focusing on employment change, traditional SSA unfortunately facilitates the ability of analysts to confound output growth with productivity improvements (Rigby and Anderson 1993; Haynes and Dinc 1997; Dinc et al.1998). That is, while one might observe that a region's employment is declining faster than the nation's in an industry, it may be that its production levels (i.e., its level of output or net taxable income) are growing faster. This can occur if the industry's productivity within the region is improving faster than is the national equivalent. Thus, by not accounting for interregional differences in labor and capital productivity, analysts will make false inferences about regional growth by focusing strictly upon employment change. Unfortunately, remedies to this condition compromise the valued uncomplicated nature of SSA.

8. Digging deeper into industry shifts

Tracking the effects of industry change had always been a core element of SSA. But it also was understood by its originators (Rosenfeld, 1959, in particular) that they were not grasping a key element of regional industry content—the magnitude of intraregional sectoral interactions, i.e., the extent of Hirschman's (1958) linkages within the target region. Hirschman proselytized the concept of further developing backward and forward linkages within an economy as a means of overcoming unbalanced growth. He noted that forward linkages were created when a particular project or program encourages investment in subsequent related streams of production within an economy. Backward linkages were created when a project or program encourages investment in the supply-chain within the economy that supports that project or program. Hirschman extoled that investments should be made in those projects and programs that have the largest total linkages (forward plus backward). He further identifies how linkages might be measured using input-output tables.

Ramajo and Márquez (2008) and Márquez et al. (2009) extend SSA to account for Hirschman's linkages. Accordingly, they estimate change in value added from a new sectoral shift–share, one in which linkages are somehow related with the sectoral mix in the analysis. The authors deem a binary configuration of weights would indicate only whether the sector exists or not in the region. Thus, such an approach would ignore both the size of a given industry and the relative size of its linkages to the rest of the economy. The authors suggest a viable notion of sectoral interaction in SSA must identify the *intensity* of an industry's relationship to other sectors in the target economic system. They therefore offer that sectoral interaction be defined as the set of flows among industries transmitted through the economic system. They thus developed sectoral neighborhood analysis akin to that used by Nazara and Hewings (2004), but, rather than using spatial weights, they use sectoral weights from the direct requirements matrix in Leontief's (1936) model for backward linkages and the direct allocation matrix in Ghosh's (1958) model. They thereby apply two new components to SSA: (1) a sectoral structural effect that is attributable to Leontief weights of sectoral composition and (2) the industry distributional effect that is attributable to Ghosh weights of an industry's sectoral disposition of its product. Using this same pair of measures in an econometric analysis of structural change on labor productivity in EU, O'Leary and Webber (2015) show that changes in intersectoral structural change appears to affect regional productivity growth and convergence.

9. **Beyond traditional SSA: Structural decomposition analysis**

Following a summary of the Ramajo-Márquez extension of SSA, it only seems natural to provide a discussion of the broader relationship between input-output (I-O) analysis and SSA. In fact, measuring changes in industry technology and, hence, changes in their mix within an economy were an original goal Wassily Leontief, who first developed I-O analysis. He recognized early on that the gap between I-O tables of different vintages for an economy identifies structural change, once price changes are netted out of them (Leontief, 1941, 1953). But the subject was not examined via a unified approach until researchers applied RAS and structural decomposition approaches to the issue.

RAS is the name currently given to the biproportional adjustment technique that became accessible to social scientists via Deming and Stephan (1940) and popularized within I-O analysis through publication of Stone (1961), Stone and Brown (1962), Bacharach (1970) and more recently Miller and Blair (2009, Section 7.4). At least in early versions of the algorithm, this data-ranking technique required an initial, prior matrix and known updates to the sums of its rows and columns, which are referred to as 'margin totals'. Naturally the prior matrix does not match with the updated margins, so, RAS, an iterative procedure. It forces first the rows and subsequently the columns of the prior matrix to be changed using proportions that relate its margins (and margins of its re-estimates after the proportions are successively updated) to the known margin updates. Miller and Blair (2009) summarize this process, noting that

where $\mathbf{A}_0$ and $\mathbf{A}_t$ are the prior and updated technology input-output direct requirements matrices, $\mathbf{r}$ is a vector that is the product of the successively applied rowwise adjustments, $\mathbf{s}$ is a vector the product of the successively applied columnwise adjustments, and the circumflex or hat (^) denotes that the vector is transformed into a diagonal matrix that has the vector on its diagonal elements and zeros elsewhere. Stone (1961) suggested that $\mathbf{r}$ reveals substitution effects across inputs and that $\mathbf{r}$ reveals fabrication effects, which not coincidentally seem related to shifts and shares, respectively. Ultimately, De Mesnard (1988, 1990) emphasized the economic interpretation of RAS by recognizing the gap between the starting and ending point of the iterative process and associate them with structural changes. It should be noted that van der Linden and Dietzenbacher (1995, 2000) suggest that some element-specific third components undoubtedly muddy perfect economic interpretations of $\mathbf{r}$ and $\mathbf{s}$.[8] But given that the economic interpretation of this third component is somewhat mystifying, meaningful interpretations of $\mathbf{r}$ and $\mathbf{s}$ remain puzzling as well. If this does not sound at least vaguely similar to early issues that attached to the regional drift component, it should. Indeed, by using a form of RAS, Oosterhaven

8 Lahr and De Mesnard (2004) suggest is a rediscovery of work by Kouevi (1965) as reported in Lecomber (1975).

and Escobedo-Cardeñoso (2011) have demonstrated that regional I-O tables can be forecasted fairly well by applying the "remainder" component, assuming it is knowable with some time lag.

The first formal identify-splitting derivation of sources of change in I-O tables, i.e., something that could be called 'structural decomposition analysis' (SDA), was performed by Leontief and Ford (1971). But it was work by Skolka (1989) that brought the approach to the forefront, and Rose and Casler (1996) who first conjectured that SDA was I-O's equivalent of SSA. In retrospect, SDA enjoys many similarities with SSA. Both focus on causes of economic change via some sort of changes in industry shares. While SSA focuses its shares via differences over space, SDA works its shares across industries via technology change (fabrication effects). SDA is clearly much more demanding in terms of time and data requirements than is SSA; on the other hand, it can produce far richer and diverse results as well.

With the above in mind, Lahr and Dietzenbacher (2016) merged SDA with SSA. They describe their approach using a seven-component SDA: (1) national labor use; (2) national labor multipliers; (3) the supplying region's own share of the regional final demand; (4) differences between regional and national final demand mixes; (5) national final demand mix; (6) shares of regional total final demand in the national final demand; and, (7) total national final demand. The key element from SDA that is missing is anything pertaining to the region's set of industry-specific direct requirements; in the decomposition they designed industry-specific requirements are harnessed only via the national labor multipliers. All remaining factors have nation-region contrasts akin to SSA decomposition components. To date, only a conference paper by Jang, Lahr and Dietzenbacher (2017) demonstrates the usefulness of such an SSA-SDA; in it the authors show how investments in South Korea's new second capital Sejong City have caused job growth in other South Korean provinces using a series of official MRIO tables for Korea—a kind of why-does-who-work-for-whom sort of situation.

10. **Shift-share in a regression framework**

A core concern with both SSA and SDA is that they can at best indicate only proximate causation and yield no statistical significance with respect to the relationships they might reveal. The first statistical analysis using SSA seems to be Weeden (1974) and not long after Berzeg (1978, 1984), who elicits a statistical rationale for the standard SSA identity using a weighted least-squares formulation. A series of papers in the mid-to-late 1970s ensured that examined the causes of the regional drift component more deeply (c.f., Harris, 1974; Chalmers and Beckhelm, 1976; Olsen, 1977; Treyz, 1977; and Treyz and Stevens, 1979). Then Patterson (1991) followed up with what he termed a full-analog regression model of the deterministic shift-share method that uses a constrained weighted least-squares regression approach; the constraints force the weighted means of the components to be zero. Interestingly, Knudsen (2000) found Berzeg's approach not only far less computationally intensive, but also more accurate. In turn, Knudsen's proposed information-theoretic regression approach appears even more promising as also demonstrated by Di Berardino et al. (2017) who analyze the average growth rate of labor productivity across regions of Italy. Ultimately, as Blien and Wolf (2002: 397) suggest it seems "the dominance of the differential shift [*the regional drift component*], which is a typical result, is at least in part an artefact of the approach." Certainly in econometrics, an improper functional form (so called "functional form misspecification") leads to bias in the model's parameters.

11. **Application to other topics**

SSA was proposed to enable an understanding the dispersion of employment in Great Britain (the *Barlow Report*) and the U.S. (Perloff et al. 1960). It has since moved far beyond this rich area of study. It has been used to examine migration (Plane, 1987; Ishikawa, 1991; Wright and Ellis, 1996), racial, gender, and other demographic changes (Smith, 1991; Daponte, 1996; Hopes, 1997; Wright and Ellis, 1997; Franklin and Plane, 2004), firm growth (Fotopoulos and Spence, 2001; Johnson, 2004), telecommunications service policy (Dinc et al., 1998b), tourism (Fuchs et al., 2000; Sirakaya et al., 2002; Toh et al., 2004; Firgo and Fritz, 2017), regional electricity consumption change (Grossi and Mussini, 2018), and even something as particular as global rice export market shares (Lakkakula et al., 2015). While the examples displayed above may seem many and topically broad, the listing is by no means exhaustive. It presents just a few topics among many, many more available to demonstrate the SSA's flexibility and accessibility in application. These two characteristics assure SSA's place in a regional analyst's tool bag.

12. **Conclusions**

Since it made its splash in an application by Perloff et al. (1960), shift-share analysis (SSA) has become one of the most heavily applied approaches for attempting to gain a basic understanding of regional economies. It retains that role along with the analysis of location quotients, which are used to identify industry concentrations, despite a cacophony of sophisticated alternatives that analysis have at their disposal. As Mulligan and Molin (2004: 115) note "apparently, the popularity of shift-share will continue to endure despite numerous scathing attacks over the years." But if nothing else is clear from this reconnaissance through the relevant literature, SSA is merely a practicable accounting identity: it never was meant to be a theory. From this perspective, the expectation that SSA become some comprehensive model of regional growth seems almost irrational. Regardless, it remains an excellent starting point for analyzing growth change and differences at the regional level—one that mathematically impaired policy wonks can generally understand.

REFERENCES

Anselin L (1988) Spatial Econometrics: Methods and Models. Kluwer Academic Publishers, Dordrecht

Arcelus F (1984) An extension of shift-share analysis. Growth and change 15(1): 3-8

Ashby L (1964) The geographical redistribution of employment: An examination of the elements of change. Survey of Current Business, US Department of Commerce, Washington

Ashby L (1968) The Shift and Share Analysis: A Reply. Southern Economic Journal 34: 42-25

Ashby L (1970) Changes in regional industrial structure: a comment. Urban Studies 7(3): 298-304

Bacharach M (1970) Biproportional Matrices & Input-Output Analysis. Cambridge University Press, Cambridge

Barff R, Knight III P (1988) Dynamic shift-share analysis. Growth and change 19(2): 1-10

Berzeg K (1978) The empirical content of shift-share analysis. Journal of regional science 18(3): 463-468

Berzeg K (1984) A note on statistical approaches to shift-share analysis. Journal of regional science 24(2): 277-285

Blien U, Wolf K (2002) Regional development of employment in eastern Germany: an analysis with an econometric analogue to shift-share techniques. Papers in Regional science 81(3): 391-414

Borts G, Stein J (1964) Economic growth in a free market. Columbia University Press, New York

Brown H (1971) The Stability of the Regional Share Component: a Reply. Journal of Regional Science 11: 113-114

Brown H (1973) Shift and Share Projections Revisited: a Reply. Journal of Regional Science 13: 121-122.

Chalmers J, Beckhelm T (1976) Shift and Share and the Theory of Industrial Location. Regional Studies 10: 15-23

Cheng S (2011) Business cycle, industrial composition, or regional advantage? A decomposition analysis of new firm formation in the United States. Annals of Regional Science 47: 147–167

Cliff A, Ord J (1981) Spatial Processes: Models and Applications. Taylor & Francis, London

Creamer D (1943) Shifts of manufacturing industries. Industrial Location and National Resources, 85-104

Daponte B (1996) Race and Ethnicity During an Economic Transition: The Withdrawal of Puerto Rican Women from New York City's Labour Force, 1960–1980. Regional Studies 30(2): 151-166

Deming W, Stephan F (1940) On a least-squares adjustment of a sampled frequency table when the expected marginal totals are known. Annals of Mathematical Statistics 11: 427–444

Di Berardino C, Mauro G, Quaglione D, Sarra A (2017) Structural change and the sustainability of regional convergence: evidence from the Italian regions. Environment and Planning C: politics and space 35: 289-311

Dinc M, Haynes K, Qiangsheng L (1998a) A comparative evaluation of shift-share models and their extensions. Australasian Journal of Regional Studies 4: 275-302

Dinc M, Haynes K, Stough R, Yilmaz S (1998b). Regional universal telecommunication service provisions in the US: efficiency versus penetration. Telecommunications Policy 22: 541-553

Dunn E (1960) A Statistical and Analytical Technique for Regional Science. Papers, Regional Science Association, 6: 97-112

Esteban-Marquillas J (1972) A reinterpretation of shift-share analysis. Regional and Urban economics 2(3): 249-255

Firgo M, Fritz O (2017) Does having the right visitor mix do the job? Applying an econometric shift-share model to regional tourism developments. The Annals of Regional Science 58(3): 469-490

Floyd C (1973) Shift and share projection models: A reformulation. The Annals of Regional Science 7(1): 40-49

Floyd C, Sirmans C (1973) Shift and Share Projections Revisited. Journal of Regional Science, 13: 115-120

Franklin R, Plane D (2004) A Shift-Share Method for the Analysis of Regional Fertility Change: An Application to the Decline in Childbearing in Italy, 1952–1991. Geographical Analysis 36(1): 1-20

Fuchs V (1959) Changes in the location of US manufacturing since 1929. Journal of Regional Science 1(2): 1-18

Fuchs M, Rijken L, Peters M, Weiermair K (2000) Modelling Asian incoming tourism: A shift-share approach. Asia Pacific Journal of Tourism Research 5(2): 1-10

Ghosh A (1958) Input-output approach in an allocation system. Economica 25: 58–64

Glickman N (1977) Econometric Analysis of Regional Systems: Explorations in Model Building and Policy Analysis. Academic Press, New York

Grossi L, Mussini M (2018) A spatial shift-share decomposition of electricity consumption changes across Italian regions. Energy Policy 113: 278-293

Hall P, Tewdwr-Jones M (2011) Urban and Regional Planning, 5th ed. Routledge, New York

Harris C (1974) Regional Economic Effects of Alternative Highway Systems. Ballinger Publishing Company Cambridge, Massachusetts

Haynes K, Dinc M (1997) Productivity change in manufacturing regions: A multifactor/shift-share approach. Growth and Change 28(2): 201-221

Haynes K, Machunda Z (1987) Considerations in extending shift-share analysis: note. Growth and Change 18(2): 69-78

Haynes K, Parajuli J (2014) Shift-share analysis: decomposition of spatially integrated systems. In: Stimpson R (ed), Handbook of Research Methods and Applications in Spatially Integrated Social Science, Edward Elgar, Cheltenham, p 315–344

Haynes K, Parajuli J (2015) Shift-share and its new extensions. In: Karlsson C, Andersson M, Norman T (eds), Handbook of Research Methods and Applications in Economic Geography, Edward Elgar, Cheltenham, p 83–116

Herzog H, Olsen R (1977) Shift-share analysis revisited: The allocation effect and the stability of regional structure. Journal of Regional Science 17(3): 441-454

Hischman A (1958) The Strategy of Economic Development. Yale University Press: Newe haven, CT

Hoppes R (1997) Shift-share analysis for regional health care policy. Regional Analysis and Policy 27(1): 35–46

Houston D (1967) The shift-share analysis of regional growth: a critique. Southern Economic Journal 33, 577-581

Isard W (1960) Methods of Regional Analysis: An Introduction to Regional Science. Massachusetts Institute of Technology Press, Cambridge, Massachusetts.

Ishikawa Y (1992) The 1970s migration turnaround in Japan revisited: A shift-share approach. Papers in Regional Science 71(2): 153-173

Jang, H., M. Lahr and E. Dietzenbacher (2017) Who works for whom in South Korea: An MRIO structural shift-share decomposition analysis, 2003-2013m paper presented at the 25th International Input-Output Conference in Atlantic City, New Jersey, June 23.

James Jr F, Hughes J (1973) A test of shift and share analysis as a predictive device. Journal of Regional Science 13(2): 223-231

Jones J (1940a) A memorandum on the location of industry. In: Barlow M (ed.) The Royal Commission on the Distribution of the Industrial Population. Appendix II: His Majesty's Stationery Office, Cmnd 6135, London.

Jones J (1940b) The Report of the Royal Commission on the Distribution of the Industrial Population. Journal of the Royal Statistical Society 103: 323-343

Keil S (1992) On the value of homotheticity in the shift-share framework. Growth and Change 23: 469-493

Klaassen L, Paelinck J (1972) Asymmetry in shift-and share analysis. Regional and Urban Economics 2(3): 256-261

Knudsen D (2000) Shift-share analysis: further examination of models for the description of economic change. Socio-Economic Planning Sciences 34(3): 177-198

Kouevi A (1965) Essai d'application propective de la méthode RAS au commerce international. Bulletin du CEPREL 5: 71-120

Kuehn J (1971) Stability of regional share components? Review of Regional Studies 42(2):70-73

Lahr M, Dietzenbacher E (2017) Structural Decomposition and Shift-Share Analyses: Let the Parallels Converge. In Regional Research Frontiers-Vol. 2 Springer, Cham, p 209-220

Lahr M, De Mesnard L (2004) Biproportional techniques in input-output analysis: table updating and structural analysis. Economic Systems Research 16(2): 115-134

Lakkakula P, Dixon B, Thomsen M, Wailes E, Danforth D (2015) Global rice trade competitiveness: a shift-share analysis. Agricultural economics 46(5): 667-676

Lamarche R, Srinath K, Ray D (2003) Correct partitioning of regional growth rates: improvements in shift-share theory. Canadian Journal of Regional Science 26(1): 121–141

Lecomber J (1975) A critique of methods of adjusting updating and projecting matrices. In: Allen I, Gossling W (eds) Estimating and Projecting Input–Output Coefficients, Input–Output Publishing, London, p 1–24

Leontief W (1936) Quantitative input and output relations in the economic system of the United States. Review of Economics and Statistics 18(3): 105–125

Leontief W (1941) Structure of American Economy. Oxford University Press, New York

Leontief W (1953) Studies in the Structure of the American Economy. Oxford University Press, New York.

Leontief W, Ford D (1971) Air pollution and the economic structure: Empirical results of input-output computations. In: Brody A, Carter A (eds.) Input-output techniques. North-Holland Publishing, Amsterdam, p 9-30

van der Linden J, Dietzenbacher E (1995) The nature of changes in the EU cost structure of production 1965–85: an RAS approach. In: Armstrong H, Vickerman R (eds) Convergence and divergence among European Regions. Pion Limited, London, p 124–139

van der Linden J, Dietzenbacher E (2000) The determinants of structural change in the European Union: a new application of RAS. Environment and Planning A 32: 2205–2229

Loveridge S, Selting AC (1998) A review and comparison of shift-share identities. International Regional Science Review, 21(1): 37-58

Markusen, A, Noponen H, Driessen K (1991) International trade, productivity, and US regional job growth: A shift-share interpretation. International Regional Science Review 14(1): 15-39

Márquez M, Ramajo J, Hewings G (2009) Incorporating sectoral structure into shift–share analysis. Growth and change 40(4): 594-618

Matilla J (1964) A Methodology of Comparative Analysis of Regional Growth: Some Technical Notes. Staff Working Paper in Economics and Statistics, No. 8, US. Department of Commerce

Mayor MM, Lopez A, Pérez R (2007) Forecasting regional employment with shift–share and ARIMA modelling. Regional Studies 41(4): 543-551

De Mesnard L (1988) Analyse de la dynamique de la structure interindustrielle française par filtrage biproportionnel. Méthode et application à la période 1970–1985. Thèse de doctorat d'Etat et Sciences Economiques, Université de Paris I Panthéon-Sorbonne, Paris

De Mesnard L (1990) Dynamique de la structure interindustrielle française. Economica, Paris

Miller E (1971) The Role of Factor Supplies in Employment Growth Some Experiments with Shift-Share Analysis. Office of System Analysis and Information, U.S. Department of Transportation (mimeographed)

Mulligan G, Molin A (2004) Estimating population change with a two-category shift-share model. The Annals of Regional Science 38(1): 113-130

Nazara S, Hewings G (2004) Spatial structure and taxonomy of decomposition in shift-share analysis. Growth and change 35(4): 476-490

O'Leary E, Webber D (2015) The role of structural change in European regional productivity growth. Regional Studies 49(9): 1548-1560

Olsen R (1977) Multiregion: A Simulation-Forecasting Model of BEA Economic Area Population and Employment. Energy Division, Oak Ridge National Laboratory

Oosterhaven J, Escobedo-Cardeñoso F (2011) A new method to estimate input-output tables by means of structural lags, tested on Spanish regions. Papers in Regional Science 90(4): 829-844

Paraskevopoulos C (1971) The stability of the regional share component: an empirical test. Journal of Regional Science 11: 107-112

Paraskevopoulos C (1974) Patterns of regional economic growth. Regional and Urban Economics 4(1): 77-105

Patterson M (1991) A note on the formulation of a full-analogue regression model of the shift-share method. Journal of Regional science 31(2): 211-216

Perloff H, Dunn E, Lampard R, Muth R (1960) Regions, Resources, and Economic Growth. Johns Hopkins University Press, Baltimore

Plane D (1987) The geographic components of change in a migration system. Geographical Analysis 19(4): 283-299

Ramajo J, Márquez M (2008) Componentes Espaciales en el Modelo ShiftShare. Una Aplicación al Caso de las Regiones Peninsulares Españolas. Estadística Española 50: 41–65

Rigby D, Anderson W (1993) Employment change, growth and productivity in Canadian manufacturing: an extension and application of shift-share analysis. Canadian Journal of Regional Science 16: 69–88

Rosenfeld F (1959) Commentaire à l'exposé de M. Dunn. Economie Appliquée 4: 531–534

Rose A, Casler S (1996) Input–output structural decomposition analysis: a critical appraisal. Economic Systems Research 8(1): 33-62

Shi C, Yang Y (2008) A review of shift-share analysis and its application in tourism. International Journal of Management Perspectives 1(1): 21-30

Sihag B, McDonough C (1989) Shift-share analysis: The international dimension. Growth and Change 20(3): 80-88

Sirakaya E, Choi H, Var T (2002) Shift-share analysis in tourism: examination of tourism employment change in a region. Tourism Economics 8(3): 303-324

Skolka J (1989) Input-output structural decomposition analysis for Austria. Journal of Policy Modeling 11: 45-66

Stevens B, Moore C (1980) A critical review of the literature on shift-share as a forecasting technique, Journal of Regional Science 20(4): 419-437

Stilwell F (1969) Regional growth and structural adaptation. Urban Studies 6: 162-178

Stokes Jr H (1974) Shift share once again. Regional and Urban Economics 4(1): 57-60

Stone R (1961) Input-Output and National Accounts. Organisation for European Economic Co-operation, Paris.

Stone R, Brown A (1962) A Computable Model of Economic Growth. Chapman & Hall, London

Thirlwall A (1967) A Measure of the Proper Distribution of Industry. Oxford Economic Papers 19: 46-58

Toh R, Khan H, Lim L (2004) Two-stage shift-share analyses of tourism arrivals and arrivals by purpose of visit: the Singapore experience. Journal of Travel Research 43(1): 57-66

Treyz G, Friedlaender A, McNertney E, Stevens B, Williams R (1977) The Massachusetts economic policy analysis (MFPA) model. Economics Department, University of Massachusetts, Amherst.

Treyz G, Stevens B (1979) Location Analysis for Multiregional Modeling paper presented at Modeling the Multi-Region Economic System; Regional Science Research Institute Discussion Paper Series, 113

Weeden R (1974) Regional Rates of Growth of Employment: An Analysis of Variance Treatment. National Institute of Economic and Social Research, Regional Papers III, Cambridge University Press

Wright R, Ellis M (1996) Immigrants and the changing racial/ethnic division of labor in New York City, 1970–1990. Urban Geography 17(4): 317–353

Zelinsky W (1958) A Method for Measuring Change in the Distribution of Manufacturing Activity: The United States, 1939-1947. Economic Geography 34(2): 95-126