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Productivity, International Trade and Reference Area Interactions in Shift-Share Analysis: Some Operational Notes

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ABSTRACT These notes discuss and illustrate two new extensions of shift-share analysis: the productivity and output model and the international trade model. We also review a general limitation of these and other shift-share-type models with respect to the interaction between reference area and the region. A possible solution to this limitation is presented. The new extensions provide better insights about the regional economy but that benefit occurs at a cost. The cost is careful consideration and compensation where relatively large regions or sectors are central to the shift-share assessment. The extensions are important in addressing earlier problems with the shift-share approach. Our solution to shift-share limitation on reference area interaction is vital if the method is to be extended to these multiple environments.

Introduction

In recent years, there has been a renewed interest in shift-share analysis and a wide variety of applications have appeared in academic journals. In addition to its standard framework for sectoral performance and interregional comparison, it has been adopted and extended in a variety of ways for applications in new areas.

Some of these new applications of shift-share model are:

1. The analysis of the impact of public decision-making (Sui 1995).
2. The change in occupational sex composition (Smith 1991).
3. The ethnic/racial division of labor (Daponte 1996; Waldinger 1996; Wright and Ellis 1996).
4. The analysis of disease death rates (Hoppes 1997).
5. The assessment of the regulationist view of history (Knudsen, Koh, and Boggs 1997).
6. The investigation of universal telephone service provision in the U.S. (Dinc et al. 1998).
7. The examination of the role of spatial structure on changes in regional manufacturing employment (Hanham and Banasick 2000).
8. The analysis of regional convergence in Europe (Esteban 2000).

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9. The generalization of an econometric analogue of the common shift-share method (Blien and Wolf 2002).
10. The analysis of the new intra-urban dynamics (Gaschet 2002).
11. The examination of the linkage between meso-structure and macro-performance (Peneder 2003).
12. The analysis of spatial structure and taxonomy of decomposition in shift-share (Nazara and Hewings 2004).
13. The estimation of population change with a two-category shift-share model (Mulligan and Molin 2004).
14. The examination of differential employment patterns for citizens and non-citizens in science and engineering (Levin et al. 2004).

During the late 1980s and 1990s, new formulations and extensions, and a wide variety of applications of shift-share analysis replaced the heavy criticisms of the model in the 1970s. (For a detailed discussion of shift-share models and comparison of various extensions see Qiansheng, Haynes, and Dinc 1997; Dinc, Haynes, and Qiangsheng 1998; Knudsen 2000; Loveridge and Selting 1998; Wadley and Smith 2003). Even with the increasing computational capability and the availability of advanced regional econometric models, shift-share has not been totally displaced. This is because in a relatively short time and with little cost, shift-share provides reasonable, easily interpreted results. Its simple logic, analytic clarity, and relatively easily accessible data requirements make the model popular among practitioners.

In this note, we discuss and illustrate two new extensions of shift-share analysis. A limitation to these models is also discussed and a possible solution is offered. The following section provides background information. Next, the new models are discussed and illustrated, the reference area limitation is identified, and a solution is presented. The final section concludes the notes.

Models

Traditional shift-share. The traditional accounting-based shift-share model decomposes economic change in a region into three additive components: the reference area component (NS), the industry mix (IM) and the regional shift (RS) (Dunn 1960). The decomposed variable may be income, employment, value added, number of establishments, or a variety of other measurements.

The reference component refers to the national economy and is called the national share (for smaller regions such as counties, it may refer to the state economy). This component measures the regional employment change that would have occurred if regional employment had grown at the same rate as the nation. The IM component measures the industrial composition of the region and reflects the degree to which the local area specializes in industries that are fast or slow growing nationally. Thus, if a region contains a relatively large share of industries that are slow/fast growing nationally, it will have a negative/positive proportionality shift. The RS measures the change in a particular industry in the region because of the difference between the industry's regional growth/decline rate and the industry's reference area growth rate. It may result from natural endowments, other comparative advantages or disadvantages, the entrepreneurial ability of the region, and/or the effects of regional policy. The total shift (TS) measures the region's changing economic position relative to the reference area and is the sum of the three components, $TS \equiv NS + IM + RS$. The three components are formulated as:

$$NS \equiv E_{ir} g_n;\ IM \equiv E_{ir}(g_{in} - g_n);\ and\ RS \equiv E_{ir}(g_{ir} - g_{in}) \tag{1}$$

where the subscript i indexes the industrial sector in region r. E_{ir}, is employment in sector i of region, r. The growth or decline in total employment in sector i of region r is g_{ir}. The growth or decline in industry i in the reference area n is g_{in}.

Assumptions are embedded in the traditional shift-share model many of which may not fully hold in the real world. It is implicitly or explicitly assumed that: (1) the regional technology is similar to the reference area; (2) regional labor is as productive as its national counterparts; (3) regional demand patterns are similar to national averages; and (4) the traditional model ignores international and interregional trade. General criticisms also centered around such issues as temporal, spatial, and industrial aggregation, theoretical content, and predictive capabilities (Knudsen 2000). These assumptions and criticisms have been the stimulus for extensions. However, the use of shift-share in the traditional form above is increasingly rare because of the growing number of additions and extensions to improve the model.

An excellent analysis and comparison of accounting-based shift-share and statistical, ANOVA-based methods (Berzeg 1978, 1984) can be found in Knudsen (2000).

Shift-share, output, and productivity change. Productivity growth is one of the most important sources of economic expansion and hence, it is a key source of the rise in output and income. There is another important aspect of productivity: its impact on employment change. Although productivity growth plays a crucial role in economic growth in the long run by attracting new businesses and hence creating new jobs, it may have a negative impact on sector-specific employment change in the short run, because it will be possible to produce the same amount of output with less labor. In that sense, understanding, measuring, and explaining productivity growth and its impact on the regional economy are very important and are a major concern to elected policy makers. This is also important in the promotion of sound economic development policies and programs.

To investigate the role of productivity and output change on regional economies, several extensions of shift-share analysis have been developed (Haynes and Dinc 1997; Ledebur and Moomaw 1983; Markusen, Noponen, and Driessen 1991; Rigby and Anderson 1993).

In the Haynes and Dinc (1997) study, the shift-share equations for labor were expressed in the following forms:

$$TS_L \equiv NS_L + IM_L + RS_L \tag{2}$$

$$NS_L \equiv NS(a_L) + NS(b_L) = \sum E_{ir}(a_{nL} + b_{nL}) \tag{3}$$

$$IM_L \equiv IM(a_L) + IM(b_L) = \sum E_{ir}[(a_{inL} - a_{nL}) + (b_{inL} - b_{nL})] \tag{4}$$

$$RS_L \equiv RS(a_L) + RS(b_L) = \sum E_{ir}[(a_{irL} - a_{inL}) + (b_{irL} - b_{inL})] \tag{5}$$

where a's represent the rate of employment change in the region (and reference area) resulting from variations in output over time with productivity constant; b's represent the rate of employment change resulting from variations in productivity over time with output constant. For a full derivation of the above, see Haynes and Dinc 1997; Haynes, Dinc, and Paelinck, 2003.

In the Haynes and Dinc (1997) study, the employment change resulting from non-labor factors' contribution was calculated as the difference between actual employment change and employment change resulting from output and productivity variation. This can be formulated as:

$$\Delta E_P = \Delta E - \Delta E_L \tag{6}$$

Where ΔE is the actual employment change over time in the region, ΔE_L is the employment change in the region or state resulting from the change in labor productivity on output. ΔE_P is the employment change resulting from the other production factors' contribution to total factor productivity.

In fact, it is possible to integrate non-labor factors, productivity and output change and their impact on employment into shift-share models. For total shift from equation (2) for sector i in region r:

$$TS \equiv [NS(a) + NS(b)] + [IM(a) + IM(b)] + [RS(a) + RS(b)] \tag{7}$$

We can rewrite the equation (7) in terms of employment growth rates as:

$$\Delta \ln E_{ir} \equiv \Delta \ln E + (\Delta \ln E_i - \Delta \ln E) + (\Delta \ln E_{ir} - \Delta \ln E_i) \tag{8}$$

This equation corresponds to the traditional shift-share model and $\Delta \ln E$ represents the national share, $(\Delta \ln E_i - \Delta \ln E)$ represents the IM, and the RS is represented by $(\Delta \ln E_{ir} - \Delta \ln E_i)$.

Equation (7) can now be rewritten in terms of employment growth as:

$$\begin{aligned} \Delta \ln E_{ir} \equiv TS \equiv & \left[\Delta \ln Q - \left(\Delta \ln \frac{Q}{E} \right) \right] \\ & + \left[\left\{ \Delta \ln Q_i - \left(\Delta \ln \frac{Q_i}{E_i} \right) \right\} - \left\{ \Delta \ln Q - \left(\Delta \ln \frac{Q}{E} \right) \right\} \right] \\ & + \left[\left\{ \Delta \ln Q_{ir} - \left(\Delta \ln \frac{Q_{ir}}{E_{ir}} \right) \right\} - \left\{ \Delta \ln Q_i - \left(\Delta \ln \frac{Q_i}{E_i} \right) \right\} \right] \end{aligned} \tag{9}$$

Equation (9) can be rearranged in terms of the Haynes–Dinc formulation, i.e., $(\Delta \ln Q)$ represents NS(a) and $(\Delta \ln \frac{Q}{E})$ represents NS(b). Similar representations hold for the remaining components.

Now:

$$\Delta \ln Q \equiv \alpha \Delta \ln K + \beta \Delta \ln E + \tau \tag{10}$$

$$\Delta \ln \frac{Q}{E} \equiv (\Delta \ln Q - \Delta \ln E) \equiv \alpha \Delta \ln K + (\beta - 1)\Delta \ln E + \tau \tag{11}$$

Here, τ represents the residual, i.e., faster-than-average regional technical progress, scale and external economies, infrastructure, etc. and can be formulated as:

$$\tau \equiv (\Delta \ln Q - \Delta \ln E) - \alpha \Delta \ln K - (\beta - 1)\Delta \ln E \tag{12}$$

$$\Delta \ln Q_i \equiv \alpha_i \Delta \ln K_i + \beta_i \Delta \ln E_i + \tau_i \tag{13}$$

$$\Delta \ln \frac{Q_i}{E_i} \equiv (\Delta \ln Q_i - \Delta \ln E_i) \equiv \alpha_i \Delta \ln K_i + (\beta_i - 1)\Delta \ln E_i + \tau_i \tag{14}$$

$$\tau_i \equiv (\Delta \ln Q_i - \Delta \ln E_i) - \alpha_i \Delta \ln K_i - (\beta_i - 1)\Delta \ln E_i \tag{15}$$

$$\Delta \ln Q_{ir} \equiv \alpha_{ir} \Delta \ln K_{ir} + \beta_{ir} \Delta \ln E_{ir} + \tau_{ir} \tag{16}$$

$$\Delta \ln \frac{Q_{ir}}{E_{ir}} \equiv (\Delta \ln Q_{ir} - \Delta \ln E_{ir}) \equiv \alpha_{ir} \Delta \ln K_{ir} + (\beta_{ir} - 1)\Delta \ln E_{ir} + \tau_{ir} \tag{17}$$

$$\tau_{ir} \equiv (\Delta \ln Q_{ir} - \Delta \ln E_{ir}) - \alpha_{ir} \Delta \ln K_{ir} - (\beta_{ir} - 1)\Delta \ln E_{ir} \tag{18}$$

In the above equations, one can estimate the value of the parameters α and β as the share of labor and capital in total cost. In doing so, it is implicitly assumed that in a given year the combination of inputs was chosen to maximize profits, and was constant during the year.

Let the price of labor and capital be P_L and P_K, respectively. The share of capital in total cost is:

$$\alpha = SK = \frac{KP_K}{LP_L + KP_K} \tag{19}$$

and similarly the share of labor in total cost is:

$$\beta = SL = \frac{LP_L}{LP_L + KP_K} \tag{20}$$

Substituting corresponding productivity changes ($\Delta \ln \frac{Q}{E}$) into the components of the equation (9) and rearranging gives:

$$\begin{aligned} \Delta \ln E_{ir} \equiv TS \equiv & [\Delta \ln Q - (\alpha \Delta \ln K + (\beta - 1)\Delta \ln E + \tau)] \\ & + [\{\Delta \ln Q_i - \Delta \ln Q\} - \{(\alpha_i \Delta \ln K_i + (\beta_i - 1)\Delta \ln E_i + \tau_i) \\ & - (\alpha \Delta \ln K + (\beta - 1)\Delta \ln E + \tau)\}] \\ & + [\{\Delta \ln Q_{ir} - \Delta \ln Q_i\} - \{(\alpha_{ir} \Delta \ln K_{ir} + (\beta_{ir} - 1)\Delta \ln E_{ir} + \tau_{ir}) \\ & - (\alpha_i \Delta \ln K_i + (\beta_i - 1)\Delta \ln E_i + \tau_i)\}] \end{aligned} \tag{21}$$

In equation (21)

$$NS(a) \equiv \Delta \ln Q \tag{22}$$

$$NS(b) \equiv (\alpha\Delta \ln K + (\beta - 1)\Delta \ln E + \tau) \tag{23}$$

$$IM(a) \equiv \Delta \ln Q_i - \Delta \ln Q \tag{24}$$

$$IM(b) \equiv \{(\alpha_i \Delta \ln K_i + (\beta_i - 1)\Delta \ln E_i + \tau_i) - (\alpha\Delta \ln K + (\beta - 1)\Delta \ln E + \tau)\} \tag{25}$$

$$RS(a) \equiv (\Delta \ln Q_{ir} - \Delta \ln Q_i) \tag{26}$$

$$RS(b) \equiv \{(\alpha_{ir}\Delta \ln K_{ir} + (\beta_{ir} - 1)\Delta \ln E_{ir} + \tau_{ir}) - (\alpha_i \Delta \ln K_i + (\beta_i - 1)\Delta \ln E_i + \tau_i)\} \tag{27}$$

Equation (21) takes into account output change and productivity change resulting from improvement of capital and labor including a residual, τ, (faster-than-average regional technical progress, scale and external economies, infrastructure, etc.) and at the same time, it maintains the additivity property of the shift-share model. Total regional growth is obtained summing over i and r.

Another important development emerges from the above discussion. $\Delta \ln E$ can be rewritten and derived:

$$\Delta \ln E + (\beta - 1)\Delta \ln E \equiv \Delta \ln Q - \alpha\Delta \ln K - \tau \tag{28}$$

$$\beta\Delta \ln E \equiv \Delta \ln Q - \alpha\Delta \ln K - \tau \tag{29}$$

finally from equation (29):

$$\Delta \ln E \equiv \frac{1}{\beta}\Delta \ln Q - \frac{\alpha}{\beta}\Delta \ln K - \frac{\tau}{\beta} \tag{30}$$

where $\frac{1}{\beta}$ is output, $\frac{\alpha}{\beta}$ is capital and $\frac{\tau}{\beta}$ is the average total productivity multiplier.

International trade and shift-share analysis. As mentioned earlier, the traditional shift-share model assumes that there is no interregional trade and the region under investigation serves only the regional economy. The Rigby and Anderson (1993) and Haynes and Dinc (1997) extensions implicitly include interregional or international trade flows by including output change into the model, but these are only marginally linked to the international dimension, which has been developed elsewhere by Sihag and McDonough (1989), Markusen, Noponen, and Driessen (1991), Noponen, Markusen, and Driessen (1997). These extensions pay special attention to international economic forces, and they are essential for the integration of regional analysis into global dynamics. Dinc and Haynes (1998a, 1998b) further refined the later extension to provide a useful framework and to ease its interpretation in examining the impact of international trade on regional employment change.

Dinc and Haynes (1998a) argued that because there is no difference between exported and domestically consumed goods in terms of the production process and the same workers produce all, the actual employment could be defined as $E \equiv E_{export} + E_{domestic}$. Therefore, any increase in exports and domestic demand will create an increase in employment. On the other hand, imports could have a negative impact on employment, because it will reduce the demand for domestically produced goods. Following the growth accounting framework in which $Q = X + D - M$ where Q is total national output, X is export, D is domestic demand and M is import, employment in a given time period can be written as:

$$E \equiv E_x + (E_d - E_m) \tag{31}$$

Here, it is assumed that domestically producing the imported goods will require the same amount of labor as in exports or domestic demand. Following the above reasoning, the output to employment ratios can be set as:

$$\frac{Q}{E} = \frac{X}{E_x} = \frac{M}{E_m} = \frac{D}{E_d} \tag{32}$$

From equation (32) they defined an export, import, and domestic demand employment variable as:

$$E_x = \frac{EX}{Q}; \quad E_m = \frac{EM}{Q} \quad and \quad E_d = \frac{ED}{Q}$$

From equation (31), one can write:

$$\Delta E \equiv \Delta E_x + \Delta E_d - \Delta E_m \tag{33}$$

Equation (33) represents employment change resulting from output growth (decline). However, there is another component that needs to be included into equation (33): employment change resulting from productivity variations. As discussed earlier, the underlying reason for that is that while productivity gain is very important for economic growth of a region in the long run, it has a negative impact on sector-specific employment change in the short run. Employment change resulting from output growth (decline) and productivity variations could be expressed as:

$$\Delta E \equiv \Delta E_q - \Delta E_p \tag{34}$$

where ΔE_q is employment change resulting from output growth (decline) and ΔE_p is employment change resulting from variations of productivity. Equation (33) can also be written as:

$$\Delta E \equiv \Delta E_x + \Delta E_d - \Delta E_m - \Delta E_p \tag{35}$$

Having established employment change resulting from different factors, this can be integrated into the above extension of shift-share. Following equations (8) and (32), national share, IM, and RS components including export, import, domestic demand, and productivity variations are derived as follows:

$$\Delta \ln E \equiv \left(\Delta \ln Q_x - \Delta \ln \frac{Q_x}{E_x}\right) + \left(\Delta \ln Q_d - \Delta \ln \frac{Q_d}{E_d}\right) - \left(\Delta \ln Q_m + \Delta \ln \frac{Q_m}{E_m}\right) \tag{36}$$

$$\Delta \ln E_i \equiv \left(\Delta \ln Q_{ix} - \Delta \ln \frac{Q_{ix}}{E_{ix}}\right) + \left(\Delta \ln Q_{id} - \Delta \ln \frac{Q_{id}}{E_{id}}\right) - \left(\Delta \ln Q_{im} + \Delta \ln \frac{Q_{im}}{E_{im}}\right) \tag{37}$$

$$\Delta \ln E_i^r \equiv \left(\Delta \ln Q_{ix}^r - \Delta \ln \frac{Q_{ix}^r}{E_{ix}^r}\right) + \left(\Delta \ln Q_{id}^r - \Delta \ln \frac{Q_{id}^r}{E_{id}^r}\right) - \left(\Delta \ln Q_{im}^r + \Delta \ln \frac{Q_{im}^r}{E_{im}^r}\right) \tag{38}$$

Substituting (36), (37), and (38) into equation (8), we obtain:

$$\begin{aligned}
\Delta \ln E_{ir} \equiv & \left[\Delta \ln Q_x - \Delta \ln \frac{Q_x}{E_x} + \Delta \ln Q_d - \Delta \ln \frac{Q_d}{E_d} - \Delta \ln Q_m + \Delta \ln \frac{Q_m}{E_m}\right] \\
& + \left[\left\{\Delta \ln Q_{ix} - \Delta \ln \frac{Q_{ix}}{E_{ix}} + \Delta \ln Q_{id} - \Delta \ln \frac{Q_{id}}{E_{id}} - \Delta \ln Q_{im} + \Delta \ln \frac{Q_{im}}{E_{im}}\right\}\right. \\
& \left. - \left\{\Delta \ln Q_x - \Delta \ln \frac{Q_x}{E_x} + \Delta \ln Q_d - \Delta \ln \frac{Q_d}{E_d} - \Delta \ln Q_m + \Delta \ln \frac{Q_m}{E_m}\right\}\right] \\
& + \left[\left\{\Delta \ln Q_{ix}^r - \Delta \ln \frac{Q_{ix}^r}{E_{ix}^r} + \Delta \ln Q_{id}^r - \Delta \ln \frac{Q_{id}^r}{E_{id}^r} - \Delta \ln Q_{im}^r + \Delta \ln \frac{Q_{im}^r}{E_{im}^r}\right\}\right. \\
& \left. - \left\{\Delta \ln Q_{ix} - \Delta \ln \frac{Q_{ix}}{E_{ix}} + \Delta \ln Q_{id} - \Delta \ln \frac{Q_{id}}{E_{id}} - \Delta \ln Q_{im} + \Delta \ln \frac{Q_{im}}{E_{im}}\right\}\right]
\end{aligned} \tag{39}$$

Equation (39) takes into account trade-related output change and productivity change, and at the same time, it maintains the additivity property of the shift-share model. Total regional growth is obtained summing over i and r.

In this application, some may argue that the logarithmic formulation of shift-share may be valid from a decomposition point of view, but it is difficult to compare with a formulation that uses base-year employment and a net growth rate, which when multiplied, yields the net change in employment. Because $\ln x_2 - \ln x_1 \approx \frac{x_2 - x_1}{x_1}$, so in the above formulation, it is reasonable to take advantage of the relatively small changes assuming differences in the results of both approaches should not be significant.

Using Barff and Knight (1988) dynamic shift-share by performing the analysis for every year and aggregating the annual results over the study period could ensure a better match between the logarithmic specification and the rate of change.[1]

Reference area–region interaction. Despite various new formulations and extensions and a wide variety of applications of the shift-share analysis, one important issue remained unnoticed: reference area–region interrelation. In the traditional model and in all of its extensions, the reference area contains total employment (income, value added, etc.) including the region's (state, county) share. In some cases, particularly at the county level of analyses, a large region or sector could dominate the reference area employment or have a large share of total employment. Hence, below/above-average regional employment growth/decline could affect the employment growth of the reference area. In such cases, the results of the shift-share analysis may be misleading by over or under estimating the components of the shift-share model used. This issue posses a serious problem for practitioners, because they generally use a given shift-share model to investigate the sectoral growth patterns of a given region, state or county, rather than comparison of regions, states, or counties. Neither earlier formulations and extensions nor the above models have explicitly dealt with the classic NS problem.

This issue can be addressed by defining the NS as the rest of the nation (region, state). It can be formulated as:

$$RA = E_n - E_r \tag{40}$$

Similarly, sectoral employment in the reference area is formulated as

$$Ra_i = E_{in} - E_{ir} \tag{41}$$

Hence, g_n and g_{in} in equations (1) become the reference area total and sectoral employment growth rates, respectively. In this way, it is possible to isolate the influence of a larger region or sector on the reference area. Because we are investigating the region under consideration relative to the reference area, this approach provides more realistic information about the region and avoids over- or underestimation problems. This approach can be applied to all extensions of the shift-share analysis. Some may argue that shift-share models then will lose one of its most attractive properties, regional comparison, but in cases where regional analysis is more important than comparison, it could be very useful.

In summary, we note that even in the simplest form of shift-share model, the region-reference area interaction is important in its own right and needs to be addressed. However, as the model gets more refined and as the level of sectoral and regional disaggregation increases, this issue becomes increasingly important because the various ratios used become more sensitive to issues of scale.

Data and Application

Given that the purpose of this note was to discuss and illustrate usefulness of the two new extensions and to see whether they could provide additional information, a very limited application is presented here. We should also note that the discussion of findings is not aimed at providing policy recommendations to decision makers of respected units under investigation. The first model is applied to two large states, Texas and New York from 1987 to 1994, and the international trade and productivity model is applied to a European Union (EU) country, Austria, where the data were readily available at the time of writing. The region-reference area issue is discussed by using data for the largest state, California, as an example.

The data used in the first models and the region-reference area interaction model were from the Annual Survey of Manufactures and the Census of Manufactures. Labor inputs were measured by hours worked rather than the number of employees, to take account of temporal, sectoral, and spatial variations in the length of the unit of work. The labor inputs include only production workers in manufacturing sectors, which covers 70–75 percent of total manufacturing employees in the United States. Output was measured by value added. To determine the share of labor in factors, the ratio of production wages to sector specific, value added was used. Wages data of production workers were from the Annual Survey of Manufactures and Census of Manufactures.

Value added data by industry were deflated using the gross national product (GNP) implicit price deflator (Economic Report of the President, 1997). An important issue was the type of deflator to be used, i.e., sector-specific deflators or the GNP deflator. At the two-digit level of aggregation, the heterogeneity of manufacturing sector products was so great that the use of GNP deflator seemed reasonable. However, as sectors were more finely disaggregated and sector homogeneity was increased (at the three- or more-digit standard industrial classification [SIC] levels), sector-specific deflator should probably have been applied.[2]

One of the other major problems researchers face in regional productivity analysis is the lack of reliable capital stock data at the state level. Three alternatives have been proposed by various researchers to overcome this problem: (1) avoid the need to measure capital services (Sveikauskas 1975); (2) constructing measures of capital; and (3) use available proxies for capital (Aaberg 1973; Moomaw 1983a; Moomaw 1983b).

Each of these alternatives has obviously some limitations. In these notes, we used the third alternative, the use of proxies for capital data, although it may involve the danger of not knowing how closely the chosen variable substitutes for the capital data are. For this approach, Aaberg (1973) suggest the use of non-labor costs per unit labor as a proxy for capital intensity. Later, Moomaw (1983a) compares productivity estimates using the non-labor income measure of capital intensity with those using the capital stock measure. He finds that "non-labor income estimates perform as well as, if not better than, the alternative . . . the manufacturing capital stock data developed for states do not provide a better proxy for capital services than non-labor income data" (Moomaw 1983a: 85). Here, non-labor income is equal to value added minus total labor costs per production worker.

Data for international trade and productivity model come from the Organization for Economic Cooperation and Devlopment Statistical Compendium (1997). In this data set, manufacturing output is given as manufacturing production in monetary terms in the local currency. The export variable is given as the share of production and the import variable as either the export/import ratio or the import penetration rate from which export and import values have been calculated. Because there was no domestic demand variable readily available, following the earlier mentioned framework, we have estimated this variable. The employment variable is given by sector and includes all manufacturing workers, both blue and white collar. Export, import, and domestic demand related employment variables have been estimated based on equation (6). All monetary values are in 1995 values. Because all these values were in local currency to maintain consistency with the reference area, the whole of EU, by using the relevant year's average exchange rates, these values were converted into U.S. dollars. Because of the lack of data for all sectors, we have investigated only eight major manufacturing sectors.

Findings and Discussion

Productivity and shift-share. The first model captures all contributing factors to productivity change as opposed to earlier productivity-related shift-share models. It is possible to investigate each of these factors separately, i.e., capital, labor, and residual (infrastructure, technological advancement, etc.). The aggregated results of the analysis are presented in Table 1. Between 1987 and 1994, manufacturing employment in Texas

TABLE 1. AGGREGATED SHIFT-SHARE RESULTS, 1987–1994.

	NS(a)	NS(b)	IM(a)	IM(b)	RS(a)	RS(b)	Total (a)	Total (b)	Total shift	Actual growth
New York	0.066	–0.057	0.031	–0.061	0.056	–0.242	0.153	–0.360	–0.207	–0.207
Texas	0.066	–0.057	–0.003	–0.013	–0.057	0.190	0.007	0.120	0.127	0.127

grew by 12.7 percent while it declined by 20.7 percent in New York. A close investigation of Table 1 reveals that the driving force of employment change in both states was productivity. New York has posted substantial productivity improvements and consequently had employment losses, although it had relatively high employment growth resulting from output change. Employment losses resulting from improvements in productivity outpaced employment gain from output growth in New York, and it ended up with a net employment decline. On the other hand, in Texas, in spite of a very small employment gain from output growth (less than 1 percent), inferior productivity performance has prevented employment decline. Hence, during the study period, Texas had a positive employment change.

Table 1, in addition to sources of employment change, illustrates regional advantages or disadvantages for the states under investigation. These figures reveal that the regional advantages (disadvantages) are the driving forces of employment growth (decline) in these states, although national trends had some impact on manufacturing employment growth.

Table 2 shows that Texas had employment growth in 15 sectors resulting mainly from inferior productivity. The largest growth took place in sector 25 followed by sectors 30, 35, 34, and 36. Texas improved its productivity in only three sectors, 20, 22, and 32. In seven sectors, national trends had a major impact on employment growth in Texas.

With the exception of the tobacco products sector, manufacturing employment in New York declined in all sectors between 1987 and 1994 (Table 3). In most of these sectors, output grew, but New York improved its productivity faster so it ended up with employment decline. In the electric sectors 36, 37, and 38, national factors had an impact on employment growth in New York during the study period. In the remaining sectors, regional factors were the driving force. Although New York suffered a decline in manufacturing employment between 1987–1994, it can be argued that it improved its competitive edge and could be better off in the long run.

As discussed earlier, an important outcome of this study is the multipliers. Table 4 shows the average multipliers for selected sectors by state. In this table, the output multiplier is represented by $\frac{1}{\beta}$, the capital multiplier by $\frac{\alpha}{\beta}$ and the residual productivity multiplier by $\frac{\tau}{\beta}$. The values of these multipliers are calculated as annual averages and can be interpreted as similar to regression coefficients.

TABLE 2. TEXAS SHIFT-SHARE RESULTS, 1987–1994.

Sector		NS(a)	NS(b)	IM(a)	IM(b)	RS(a)	RS(b)	Total (a)	Total (b)	Total shift	Actual growth
20	Food and kindred products	0.066	–0.057	–0.174	0.294	0.039	–0.037	–0.069	0.2	0.131	0.131
22	Textile mills products	0.066	–0.057	0.035	–0.11	0.023	–0.025	0.124	–0.192	–0.068	–0.068
23	Apparel and textile products	0.066	–0.057	–0.005	–0.091	–0.08	0.33	–0.018	0.182	0.164	0.164
24	Lumber and wood products	0.066	–0.057	–0.045	0.096	0.088	0.028	0.11	0.067	0.177	0.177
25	Furniture and fixtures	0.066	–0.057	–0.083	0.071	–0.169	0.579	–0.185	0.593	0.408	0.408
26	Paper and allied products	0.066	–0.057	–0.169	0.221	–0.074	0.206	–0.177	0.37	0.193	0.193
27	Printing and publishing	0.066	–0.057	–0.023	0.023	0.013	0.007	0.056	–0.027	0.029	0.029
28	Chemical and allied products	0.066	–0.057	0.021	0.016	–0.225	0.331	–0.137	0.29	0.153	0.153
29	Petroleum and coal products	0.066	–0.057	0.074	–0.05	–0.284	0.259	–0.144	0.152	0.009	0.009
30	Rubber and miscellaneous plastics	0.066	–0.057	–0.141	0.326	–0.013	0.131	–0.087	0.4	0.313	0.313
31	Leather products	0.066	–0.057	0.218	–0.548	–0.089	0.629	0.195	0.025	0.22	0.22
32	Stone, glass, and glass products	0.066	–0.057	–0.053	–0.012	0.126	–0.207	0.14	–0.275	–0.136	–0.136
33	Primary metal industries	0.066	–0.057	0.018	–0.022	–0.277	0.469	–0.193	0.39	0.198	0.198
34	Fabricated metal products	0.066	–0.057	–0.055	0.05	–0.146	0.386	–0.135	0.379	0.244	0.244
35	Machinery and equipment	0.066	–0.057	–0.089	0.141	–0.01	0.244	–0.033	0.329	0.296	0.296
36	Electronic and electrical equipment	0.066	–0.057	0.136	–0.157	0.175	0.06	0.378	–0.154	0.223	0.223
37	Transportation equipment	0.066	–0.057	0.085	–0.19	–0.079	0.035	0.072	–0.212	–0.14	–0.14
38	Instruments and related products	0.066	–0.057	0.219	–0.373	–0.074	0.106	0.212	–0.324	–0.112	–0.112
39	Miscellaneous manufacturing	0.066	–0.057	–0.028	0.061	–0.018	0.088	0.02	0.093	0.112	0.112

TABLE 3. NEW YORK SHIFT-SHARE RESULTS, 1987–1994.

Sector		NS(a)	NS(b)	IM(a)	IM(b)	RS(a)	RS(b)	Total (a)	Total (b)	Total shift	Actual growth
20	Food and kindred products	0.066	–0.057	–0.174	0.294	0.039	–0.037	–0.069	0.2	0.131	0.131
22	Textile mills products	0.066	–0.057	0.035	–0.11	0.023	–0.025	0.124	–0.192	–0.068	–0.068
23	Apparel and textile products	0.066	–0.057	–0.005	–0.091	–0.08	0.33	–0.018	0.182	0.164	0.164
24	Lumber and wood products	0.066	–0.057	–0.045	0.096	0.088	0.028	0.11	0.067	0.177	0.177
25	Furniture and fixtures	0.066	–0.057	–0.083	0.071	–0.169	0.579	–0.185	0.593	0.408	0.408
26	Paper and allied products	0.066	–0.057	–0.169	0.221	–0.074	0.206	–0.177	0.37	0.193	0.193
27	Printing and publishing	0.066	–0.057	–0.023	0.023	0.013	0.007	0.056	–0.027	0.029	0.029
28	Chemicals and allied products	0.066	–0.057	0.021	0.016	–0.225	0.331	–0.137	0.29	0.153	0.153
29	Petroleum and coal products	0.066	–0.057	0.074	–0.05	–0.284	0.259	–0.144	0.152	0.009	0.009
30	Rubber and miscellaneous plastics	0.066	–0.057	–0.141	0.326	–0.013	0.131	–0.087	0.4	0.313	0.313
31	Leather products	0.066	–0.057	0.218	–0.548	–0.089	0.629	0.195	0.025	0.22	0.22
32	Stone, class, and glass products	0.066	–0.057	–0.053	–0.012	0.126	–0.207	0.14	–0.275	–0.136	–0.136
33	Primary metal industries	0.066	–0.057	0.018	–0.022	–0.277	0.469	–0.193	0.39	0.198	0.198
34	Fabricated metal products	0.066	–0.057	–0.055	0.05	–0.146	0.386	–0.135	0.379	0.244	0.244
35	Machinery and equipment	0.066	–0.057	–0.089	0.141	–0.01	0.244	–0.033	0.329	0.296	0.296
36	Electronic and electrical equipment	0.066	–0.057	0.136	–0.157	0.175	0.06	0.378	–0.154	0.223	0.223
37	Transportation equipment	0.066	–0.057	0.085	–0.19	–0.079	0.035	0.072	–0.212	–0.14	–0.14
38	Instruments and related products	0.066	–0.057	0.219	–0.373	–0.074	0.106	0.212	–0.324	–0.112	–0.112
39	Miscellaneous manufacturing	0.066	–0.057	–0.028	0.061	–0.018	0.088	0.02	0.093	0.112	0.112

TABLE 4. AVERAGE MULTIPLIERS FOR SELECTED SECTORS, 1987–1994.

	Output multiplier		Capital multiplier		Productivity multiplier	
	NY	TX	NY	TX	NY	TX
Fabricated metal products (34)	3.14	3.55	–2.14	–2.55	–0.02	0.10
Industrial machinery and equipment (35)	4.34	5.25	–3.34	–4.25	–0.06	0.21
Electric & electronic equipment (36)	5.62	8.91	–4.62	–7.91	–0.10	0.31
Transportation equipment (37)	3.86	4.55	–2.86	–3.55	–0.16	–0.06
Instruments and related products (38)	9.73	6.96	–8.73	–5.96	–0.36	–0.09

Recall that this is an ex-post analysis and hence reflects the realized growth or decline based on multipliers. Therefore, a positive sign under the productivity multiplier heading is an indicator of poor productivity performance of a state in a given sector. In fact, the preferred sign of this multiplier is negative. Table 4 provides valuable information for the state industrial policy makers about understanding what happened in the state.

International trade and productivity model. As discussed earlier, the international-trade-related shift-share model is illustrated by applying it to Austria. In this application, Austria represents the region and the EU represents the reference area. Table 5 shows the results for the international trade and productivity shift-share model by sector from 1980 to 1995. During this period, Austrian manufacturing employment significantly declined in four sectors. In the remaining four sectors, employment grew over the study period.

In the declining sectors, the driving factors were increasing imports and productivity improvements in exported and domestically consumed goods production. The reference area trend also had an important impact on employment change. Austria had a relatively inferior IM, in which four sectors had a decline in exports and growth in imports. The bad news was that in sectors where exports declined, imports grew. The industrial structure had also suffered declining productivity in both export and domestic production in all sectors with the exception of the fabricated metal products sector.

In terms of regional advantage, Austria had an obvious advantage in export and domestic production and hence in employment growth. Another regional advantage Austria enjoyed during this period was the improvement in productivity in both exporting and domestically oriented sectors. Although this caused a decline in employment, in the long run, it could help improve its competitiveness. We should note that the shift-share results

TABLE 5. AUSTRIA, INTERNATIONAL TRADE AND PRODUCTIVITY SHIFT-SHARE RESULTS, 1980–1995.

	European Union share						Industry mix						Country share						Total shift	Actual change
	Exp	Imp	Dom	E Prod	I Prod	D Prod	Exp	Imp	Dom	E Prod	I Prod	D Prod	Exp	Imp	Dom	E Prod	I Prod	D Prod		
Food, beverage, and tobacco	0.35	–0.35	–0.06	–0.15	0.08	–0.08	–0.01	0.05	0.01	0.17	–0.06	0.11	0.37	–0.38	0.35	–0.21	0.16	–0.21	**0.16**	**0.13**
Textile, apparel, leather	0.35	–0.35	–0.06	–0.15	0.08	–0.08	–0.24	0.11	–0.42	0.24	–0.03	0.17	0.03	0.13	0.21	–0.20	0.06	–0.20	**–0.35**	**–0.33**
Wood and furnishings	0.35	–0.35	–0.06	–0.15	0.08	–0.08	0.02	–0.08	0.03	0.28	–0.13	0.21	0.44	–0.35	0.92	–0.64	0.56	–0.64	**0.42**	**0.39**
Paper and printing	0.35	–0.35	–0.06	–0.15	0.08	–0.08	0.07	–0.06	0.15	0.24	–0.10	0.11	0.27	–0.24	0.39	–0.56	0.49	–0.50	**0.04**	**0.03**
Chemical	0.35	–0.35	–0.06	–0.15	0.08	–0.08	0.04	0.05	–0.02	0.08	–0.10	0.14	0.28	–0.33	0.14	–0.04	0.13	–0.17	**–0.02**	**–0.01**
Non-metallic	0.35	–0.35	–0.06	–0.15	0.08	–0.08	–0.32	0.12	–0.08	0.27	0.05	0.07	0.08	0.16	0.58	–0.46	0.21	–0.33	**0.14**	**0.10**
Basic metal	0.35	–0.35	–0.06	–0.15	0.08	–0.08	–0.59	0.54	–0.38	0.42	–0.43	0.41	0.36	–0.28	0.36	–0.67	0.74	–0.73	**–0.45**	**–0.45**
Fabricated metal	0.35	–0.35	–0.06	–0.15	0.08	–0.08	0.12	–0.18	0.18	–0.18	0.19	–0.21	0.44	–0.34	0.39	–0.44	0.50	–0.48	**–0.23**	**–0.22**

Note: Exp, exports; Imp, imports; Dom, domestic demand; E prod, productivity in exports; I prod, productivity in imports; D prod, productivity in domestic production.

do not exactly match the actual change perfectly, although the difference is not significant. This may have resulted from the earlier-discussed logarithmic formulation.

Region-reference area interaction. To demonstrate the difference between the traditional shift-share and the new reference area adjusted approach, we have examined seventeen manufacturing sectors (at the two-digit SIC level) in California from 1987 to 1994.

Table 6 shows employment change in California, in the U.S. (including CA), in the reference area (the rest of the nation excluding CA), and employment share of California from 1987 to 1994. A close investigation of Table 6 reveals that California had an average of 11 percent share in total U.S. manufacturing employment between 1987 and 1994. Its share in some sectors reached to over 15 percent. Further, the growth/decline patterns of the region and the reference area are quite different. Hence, inclusion or exclusion of California affects the employment change of the reference area and alters the shift-share results in all three components.

Table 7 presents the results of the two approaches. A close investigation of the Table 7 reveals that in some sectors in which California grows faster than the rest of the nation, traditional shift-share underestimates the RS effect and overestimates the IM and national share effects. Similarly, if the rest of the nation grows faster in these sectors, the reverse is true. The last three columns of Table 7 show the magnitude of the difference between the two approaches. The traditional shift-share results in this case are misleading and could cause incorrect policy signals. On the other hand, the new approach shows the corrected situation and can give a better perspective on the economic structure of the state.

Conclusion

In these notes, two new extensions of the shift-share model were discussed and illustrated. Further, the region-reference area interaction issue was presented with an appropriate solution.

The empirical analyses demonstrated that the new models are in fact useful and contribute to the general knowledge of regional modeling. Inclusion of all contributing factors to productivity and hence employment change provides a deeper understanding of the regional economy and employment change.

The productivity interpretation in this study may seem controversial in that productivity is presented as responsible for employment decline. Although such decline is accurate in the short run as it releases labor and capital for other uses, in the long run, productivity improvement can attract more business to the region and help in the creation of new ones. Therefore, it should be seen as a positive sign in the long run for a region or country even if it produces capital reallocation and employment dislocation in the short run.

International trade and productivity shift-share model extensions can obviously enhance the contribution of other models and give practitioners new tools to determine which sectors are export sensitive and which sectors should be monitored closely with respect to import impacts.

Our final analysis of reference area interaction showed that when investigating large states (regions, counties) or sectors, the new approach for managing interaction effects is

TABLE 6. EMPLOYMENT CHANGE IN CALIFORNIA, IN U.S. (INCLUDING CA) AND IN REFERENCE AREA (EXCLUDING CA), 1987–1994.

SIC	Sectors	CA employment change	U.S. employment change	RA employment change	CA average employment share
20	Food and kindred products	0.04	0.04	0.04	0.11
23	Apparel and textile products	0.16	–0.12	–0.17	0.13
24	Lumber and wood products	–0.19	0.03	0.06	0.09
25	Furniture and fixtures	–0.29	–0.03	0.01	0.11
26	Paper and allied products	0.03	0.02	0.02	0.06
27	Printing and publishing	0.01	0.01	0.01	0.11
28	Chemicals and allied products	0.09	0.01	0.01	0.07
29	Petroleum and coal products	0.02	–0.03	–0.04	0.13
30	Rubber and miscellaneous plastics	0.06	0.16	0.17	0.09
32	Stone, class, and glass products	–0.17	–0.07	–0.06	0.09
33	Primary metal industries	–0.27	–0.05	–0.04	0.05
34	Fabricated metal products	–0.1	–0.03	–0.03	0.1
35	Machinery and equipment including computers	–0.16	–0.01	0.01	0.11
36	Electronic and electrical equipment excluding computers	–0.11	–0.06	–0.05	0.16
37	Transportation equipment	–0.45	–0.15	–0.1	0.15
38	Instruments and related products	–0.23	–0.17	–0.15	0.19
39	Miscellaneous manufacturing	0.08	0.03	0.02	0.1
	Total	–0.12	–0.03	–0.02	0.11

TABLE 7. CALIFORNIA SHIFT-SHARE RESULTS, 1987–1994.

SIC		Traditional shift-share				New formulation				Difference		
		NS	IM	RS	TS	NS	IM	RS	TS	NS	IM	RS
20	Food and kindred products	–5,342	12,466	–224	6,900	–3,322	10,479	–258	6,900	–2,020	1,986	34
23	Apparel and textile products	–3,632	–11,912	36,344	20,800	–2,120	–18,860	41,780	20,800	–1,512	6,947	–5,435
24	Lumber and wood products	–2,239	2,876	–12,737	–12,100	–1,560	3,418	–13,958	–12,100	–679	–541	1,221
25	Furniture and fixtures	–1,987	–185	–15,227	–17,400	–1,356	1,172	–17,216	–17,400	–631	–1,357	1,988
26	Paper and allied products	–1,148	1,743	405	1,000	–714	1,293	422	1,000	–434	451	–17
27	Printing and publishing	–5,514	6,201	–187	500	–3,570	4,323	–253	500	–1,944	1,879	66
28	Chemicals and allied products	–1,768	2,429	3,939	4,600	–1,088	1,498	4,190	4,600	–680	931	–251
29	Petroleum and coal products	–446	–24	670	200	–275	–269	743	200	–172	245	–73
30	Rubber and miscellaneous plastics	–2,806	15,870	–9,364	3,700	–1,800	15,853	–10,353	3,700	–1,005	17	988
32	Stone, glass, and glass products	–1,762	–2,331	–4,106	–8,200	–1,216	–2,442	–4,542	–8,200	–547	110	436
33	Primary metal industries	–1,183	–644	–6,973	–8,800	–818	–658	–7,323	–8,800	–364	14	350
34	Fabricated metal products	–4,794	–581	–8,725	–14,100	–3,215	–1,212	–9,673	–14,100	–1,579	631	948
35	Machinery and equipment	–6,781	4,854	–31,572	–33,500	–4,536	6,526	–35,490	–33,500	–2,245	–1,672	3,917
36	Electronic and electrical equipment	–7,878	–7,671	–13,851	–29,400	–5,136	–7,671	–16,593	–29,400	–2,742	0	2,742
37	Transportation equipment	–11,053	–31,658	–72,389	–115,100	–7,906	–22,046	–85,147	–115,100	–3,147	–9,611	12,758
38	Instruments and related products	–6,331	–23,329	–10,739	–40,400	–4,178	–22,864	–13,358	–40,400	–2,153	–465	2,619
39	Miscellaneous manufacturing	–1,325	2,112	1,813	2,600	–862	1,520	1,943	2,600	–462	592	–130

interpretively more helpful than the traditional shift-share approach of ignoring such interaction. This new approach can provide significantly better results for practitioners.

Clearly, shift-share analysis continues to evolve and with that evolution, its usefulness to practitioners should become more effective. Hence, investment in understanding its basic principles will continue to have strong operational pay-offs in the future.

NOTES

1. We would like to thank one of the anonymous referees for bringing this to our attention.
2. An anonymous referee proposed an interesting option. This would be to compare the results of the use of the finer sector-specific deflator with the use of GNP deflator in order to select the point of divergence because of heterogeneous/homogeneous difference so that right deflator could be selected. This is a valid suggestion and would make an important paper in its own right but, of course, is beyond the scope of these notes.

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