A COMPARATIVE EVALUATION OF SHIFT-SHARE MODELS AND THEIR EXTENSIONS[1]

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ABSTRACT The expansion of shift-share methods and approaches has lead to a variety of modifications and extensions. These extensions have been created for different purposes. The result is a confusing array of shift-share modeling options. This paper attempts to offer an evaluation and comparison of the different shift-share formulations. First we summarize and categorize recent shift-share developments for comparative assessment. Second, we apply a common database to a subset of these methods to illustrate their differences and contributions.

1. INTRODUCTION

Shift-share analysis is a useful method for examining regional growth and decline of industrial performance, and interregional comparison. It is a widely used technique for regional analysis due to its simple logic, analytic clarity and relatively easily accessible data requirements. The shift-share method is very practical in assessing the impacts of industrial restructuring on regional and local economies and for providing guidance for industrial targeting. Hence, since its introduction in 1960, it has been adopted and applied to a variety of regional issues including: regional analysis of manufacturing labour productivity (Ledebur and Moomaw, 1981; Rigby and Anderson, 1993; Haynes and Dinc, 1997); the impact of transportation employment on regional growth (Toft and Stough, 1986); regional economic forecasting (Tervo and Okko, 1983); regional differences in employment growth (Qiangsheng *et al.*, 1997; Haynes and Machunda, 1987); regional demographic change (Plane, 1989); the analysis of the impact of public decision making (Sui, 1995); migration turnaround (Ishikawa, 1992); the change in occupational sex composition (Smith, 1991); and the ethnic/racial division of

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[1] We would like to thank Matthew Peter and an anonymous referee for their constructive comments on an earlier version of the paper.

labour (Wright and Ellis, 1996; Daponte, 1996 and Waldinger, 1996).

At the same time, however, it has been heavily criticized. These criticisms, discussed in the following sections, have directed efforts to addressing some of the weaknesses of the traditional shift-share model. As a result, several extensions and new formulations of the model have been made and applied to some regions for different purposes. Although there have been reviews and evaluations of these extensions and new formulations in isolation, empirical comparative assessment of most of these formulations are not available. Furthermore, no systematic comparisons across a single database have been attempted. Therefore, it is difficult to determine which of these alternative formulations provide better analytical insight into the economic performance of the region(s), or for what purpose or advantage these specific extensions are best suited.

This paper primarily aims to fill this gap by evaluating and comparing some of the well-known and widely applied extensions of the shift-share model. Beyond organizing and categorizing these extensions and formulations for effective utilization we also test and compare these extensions by using a common data set. We apply this database to all of those alternative models, which are identifiably different.

The organization of the paper is as follows. The next section reviews the evolution of the shift-share model. The third section surveys the responses to earlier criticisms and examines the extensions of the base model with the emphasis on recent formulations. Models are organized into a set of operational categories for pedagogical as well as analytical purposes. Then a common data set is applied to all major extensions. Next, we provide a comparison of alternatives. A conclusion follows.

2. THE TRADITIONAL SHIFT-SHARE MODEL

The traditional shift-share model examines economic change (i.e., growth or decline) in a region by decomposing it into three components: national share, industrial mix, and regional share. The decomposed variables may be employment, income, output, population or a variety of other economic factors that are imbedded in different hierarchical levels. Hence, the method serves as one of the most relevant techniques for regional analysis based on regional and sectoral decomposition.

For ease of interpretation of different formulations in the following sections, a common notation is used. Hence, in the formulations below, the subscripts i, r and n index the industrial sector, the region and the nation (reference area) respectively. E represents employment and e is the growth (decline) in employment. Unless noted otherwise E represents initial employment level of industry in the region or nation.

The early shift-share models used in Perloff *et al* (1960) focused on total regional employment and had only two components, i.e., total shift *(TS)* and the differential shift *(DS)*, for the region:

$$TS = \Sigma E_{ir,t} - \Sigma E_{ir,t-1} e_{ir} \tag{1}$$

$$DS = \Sigma E_{ir}(e_{ir} - e_{in}) \tag{2}$$

Concerned with total employment shifts, Dunn (1960) introduced differential rates of growth in individual industries, which is equivalent to the industry mix *(IM)* effect discussed below. This early work was mainly intended to be used as an ex post analysis technique. Ashby (1970) introduced a three-component model and began to look into regional shifts in individual industries. His model consists of the following components: National Share *(NS)*, industry mix *(IM)* and regional share *(RS)*.

$$\Delta E_{ir} \equiv NS_i + IM_i + RS_i \tag{3}$$

The reference area 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 could have occurred if regional employment had grown at the same rate as the nation.

$$NS_i \equiv E_{ir} e_n \tag{4}$$

The industrial mix (composition shift, or structural effect) 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, a region contains a relatively large share of industries that are slow (fast) growing nationally will have a negative (positive) proportionality shift.

$$IM_i \equiv E_{ir}(e_{in} - e_n) \tag{5}$$

The regional share (differential shift or competitive effect) measures the change in a particular industry in the region due to the difference between the industry's regional growth (decline) rate and the industry's reference area growth rate. This component indicates growth or decline in industries due to differences in growth rates of the same industry between the region and the nation as a result of the natural endowments, other comparative advantages or disadvantages, entrepreneurial ability, and effects of regional policy. Even though, we do not always know what these advantages or disadvantages are, we can determine by looking at the differential shift component which industries are performing particularly well in the region.

$$RS_i \equiv E_{ir}(e_{ir} - e_{in}) \tag{6}$$

The total shift measures the region's changing economic position relative to the reference area, which is the sum of three components.

$$TS \equiv E_{ir} e_n + E_{ir}(e_{in} - e_n) + E_{ir}(e_{ir} - e_{in}) \tag{7}$$

This latter formulation is generally referred to as the classical shift-share model.

The original purpose was to emphasize the role of regional change for a region-specific industry. The regional shift or competitive component is intended to measure the relative performance of a region for a specific industry. A positive shift is associated with the comparative advantage of the region for that industry, and vice versa. This component is seen the most important component of the model because it is unique to region and contains employment growth effects of regional policy, and hence it is the focus of interest for studies related to regional policies.

Like many other models, the traditional shift-share model embodies some assumptions most of which may not hold in the real world. Some of them are: (1) the regional technology is similar to the reference area (nation), (2) regional labour is as productive as its national counterparts, (3) regional demand patterns are similar to national averages, and (4) the model ignores international and interregional trade. In the following years, these assumptions have been the sources of some criticisms and at the same time new extensions.

3. CRITICISMS AND EXTENSIONS

Criticisms and debates over the usefulness and accuracy of this technique have prompted shift-share users and researchers to seek alternative formulations and solutions. Shift-share reformulation and extension as well as its integration with other regional analysis techniques have been explored by many authors in an attempt to broaden its application and to improve its accuracy. In the course of over forty years since its first appearance, we are fortunate to see that many authors have contributed to the development of this technique.

As noted by Haynes and Machunda (1988), the theoretical interest in shift-share as a method for regional analysis has brought forth two classes of important contributions. On the one hand, authors have turned to other methods in order to develop analytic procedures that serve to overcome certain inherent shortcomings of the classical shift-share methods while performing similar functions. On the other hand, attempts have been made to address those criticisms of the classical models by alternative formulations and extensions of the traditional shift share decomposition.

The first group, represented by Klaassen and Paelinck (1972), Sakashita (1973) Emmerson, Ramanathan and Ramm (1975), Buck and Atkins (1976), Theil and Gosh (1980), Berzeg (1984) and Kurre and Weller (1989), intended to provide a theoretical justification for shift-share analysis to address the asymmetry problem of the traditional shift-share model when employed to investigate sources of growth differentials between a pair of regions (Haynes and Machunda, 1987). Theil and Gosh (1980), later extended by Haynes and Machunda (1988), turn to information theory in order to justify the use of the RAS method within the shift-share framework, but they admit that RAS method does not provide an exhaustive decomposition of regional employment/output levels.

The second group among others represented by Esteban-Marquillas (1972), Arcelus (1984), Haynes and Machunda (1988), Barff and Knight (1988), Sihag and

McDonough, (1989); McDonough and Sihag, (1991); Rigby and Anderson (1993), Haynes and Dinc (1997), and Qiansheng (1997). This group intended to address some of the criticisms and weaknesses of the traditional shift-share model by extending it.

One of the criticisms shift-share model suffered most is that growth resulting from inter-industry linkage and secondary multiplier effects are not explicitly isolated but are included in the regional share (competitive) component whereas they should be included in the industry mix component. The interweaving of these two effects causes an asymmetry problem when two regions with different base period weights are compared. Consequently, these two effects are not statistically independent of each other. Further, increasing spatial dependence between industries and regions makes this issue rather complex. The later problem cannot be addressed unless an interregional input-output or some sort of spatial interaction model is appropriately incorporated.

Another criticism is that the regional share component is unstable over time and the degree of instability varies among industries, though stability of the regional share component is important for prediction purposes but not for description. The validity of this criticism has been debated, e.g., between Houston (1967) and Ashby (1967). The stability of the regional share component over time is a critical condition for projection and policy impact studies. Brown (1969) tests different models and found some models predict better than others. After evaluating and comparing different models and results of shift-share, Stevens and Moore (1980) argues that the level of stability of the regional shift (*RS*) component relies on the models used.

Esteban-Marquillas (1972) addresses the industry mix and regional share interweaving problem by adding a fourth component: allocation effect. To measure allocation effect and to solve the problem of interwoven effects (i.e., the competitive position and industry-mix effects are interwoven as they both depend on industrial structure), he introduced the concept of homothetic employment, $\hat{e}$:

$$\hat{e}_i = Er(E_{in}/E_n) \tag{8}$$

The homothetic employment is defined as "the employment that sector *i* of region *r* would have if the structure of the employment in such a region were equal to the national structure" (Esteban-Marquillas, (1972, p. 251). To remove the competitive position of all regional structural influence, the homothetic employment is used to replace the effective employment. In this way, it is possible to decompose the regional share (competitive) component into two sub-components: regional share or competitive effect (RS_i) and allocation effect (Ae_i). Thus, the Esteban-Marquillas extension becomes:

$$\Delta E_{ir} \equiv NS_i + IM_i + RS_i + Ae_i \tag{9}$$

$$\equiv E_{ir}e_n + E_{ir}(e_{in}-e_n) + \hat{e}_{ir}(e_{ir}-e_{in}) + (E_{ir}-\hat{e}_{ir})(e_{ir}-e_{in})$$

In this formulation, while regional share (RS_i) measures the advantages or disadvantages of sector i in the region relative to the reference area, allocation effect (Ae_i) captures the the region's degree of specialization in sector i. This extension also addresses the above mentioned unstability problem of the regional share component.

Herzog and Olsen (1977) employed this reformulation to investigate employment growth between 1960 and 1970 among U.S. regions. They found that the new technique expands the analytic properties of shift-share analysis, but that interpretations based on empirical implementation are very sensitive to the temporal representation of regional structure in the new formulation.

Arcelus (1984) further discusses the Esteban-Marquillas "allocation effect" and modifies the Estaban-Marquillas formulation in two directions. In the first direction, he applies homothetic employment concept to national share and industry mix components and argues that this modification provides a more comprehensive conceptual framework for the analysis of the two reference area components. The second direction is focused on the regional effects. In this extension, Arcelus (1984) breaks down the regional share component into two sub-components: regional growth effect (RG_i) and regional industry mix effect (RI_i). He defines

$$\Delta E_{ir} \equiv NS_i + IM_i + RG_i + RI_i \tag{10}$$

$$RG_i = \hat{e}_{ir}\,(e_{in}-e_n)+(E_{ir}-\hat{e}_{ir})(e_{in}-e_n) \tag{11}$$

$$RI_i = \hat{e}_{ir}\,[(e_{ir}-e_r)-(e_{in}-e_n)]+(E_{ir}-\hat{e}_{ir})[(e_{ir}-e_r)-(e_{in}-e_n)] \tag{12}$$

RG_i is the regional counterpart of the national share (NS_i) and measures the employment growth resulting from differences between regional and national growth. RI_I, on the other hand is seen the regional equivalent of national industry mix (IM_i) captures the industry's differential share between the region and the nation. According to Arcelus (1984) these two sub-components may be considered as endogenous to the economy of the region and hence reflect the outcomes of regional policies. He also argues that the allocation effect is related to the location quotient of the region:

$$L_{ir} = (E_{ir}/E_r)/(E_{in}/E_n) = E_{ir}/\hat{e}_{ir} \tag{13}$$

$$(E_{ir}-\hat{e}_{ir}) = E_{ir}\,[1-(1/L_{ir})] = \hat{e}_{ir}\,(L_{ir}-1) \tag{14}$$

where L_{ij} is the location quotient for industry i in region r. This relationship enables the shift-share analysis to provide rough estimates of the effects of local and export markets on e_i (Arcelus, 1984).

However, authors such as Stokes(1974), Richardson (1978), Herzog and Olsen (1979), and Dawson (1982) argued that the kind of shift-share extensions as suggested by Esteban-Marquillas lost the property of region-to-region additivity or the aggregation-disaggregation symmetry which has always been one of the attractive qualities of the shift-share method. Haynes and Machunda (1987), on the other hand, demonstrated that both Esteban-Marquillas and Arcelus extensions possess this region-to-region additivity property. More recently, Keil (1992) examined the value of both Esteban-Marquillas (1972) and Arcelus (1984) homotheticity formulation and concluded that they provide statistically independent measures of the differential shift effects.

Qiangsheng (1997) raised additivity and interweaving questions once again and argued that the problem of sectoral additivity can be addressed or neutralized when the variables are combined in an integrated manner to explain sectoral change. According to him, Arcelus' (1984) extension provides a good framework for such an approach. Since Arcelus did not go far enough as to elaborate on how his model could be used to explain regional sectoral change and what each new component can do, Qiangsheng argued, a new interpretation is required.

Since *IM* and *RI* are two different effects that contribute to regional growth, they should be dealt with as separate effects in regional analysis. The regional industry mix (*RI*) component explains the differential sectoral growth rate between the region and the nation, or the absolute advantage (disadvantage) of the sector without being influenced by the regional industrial base. The conventional regional shift component, on the other hand, explains the relative advantage (disadvantage) of the sector in the region regardless of the region's industrial structure. The total sectoral mix effect (*TI*) is therefore the net sectoral advantage for the region.

$$\begin{aligned} TI_{ij} &= IM_{ij} + RI_{ij} \\ &= E_{ir}(e_{in} - e_n) + E_{ir}[(e_{ir} - e_r)-(e_{in} - e_n)] \quad (15) \\ &= E_{ir}(e_{ir} - e_r) \end{aligned}$$

The extended new formulation now looks as follows:

$$\begin{aligned} \Delta E_{ir} &= NS_i + IM_i + RS_i \\ &= NS_i + IM_i + RG_i + RI_i \quad (16) \\ &= NS_i + TI_i + RG_i \end{aligned}$$

where,

$$NS_i = E_{ir}\, e_n \quad (17)$$

$$IM_i = E_{ir}\,(e_{in} - e_n) \quad (18)$$

$$RS_i = E_{ir}\,(e_{ir} - e_n) \quad (19)$$

$$RI_i = E_{ir}\,[(e_{ir} - e_r)-(e_{in} - e_n)] \quad (20)$$

$$TI_i = E_{ir}\,(e_{ir} - e_r) \quad (21)$$

$$RG_i = E_{ir}\,(e_r - e_n) \quad (22)$$

The emergence of new components and formulations requires new interpretations. Equations in (16) are all symmetric formulations. Their separate expressions are intended to maintain a meaningful and symmetric structure valid for empirical analysis. However, these equations can be combined to form a single equation:

$$\Delta E_{ir} = NS_i + IM_i + RS_i + RI_i + TI_i + RG_i + TS_i \quad (23)$$

where,

$$TS_i = E_{ir}[(e_r - e_{ir}) + (e_{in} - e_{ir})] \tag{24}$$

The introduction of the allocation effect or the total shift component (TS) is to balance the formulation structure. This component equals the negative sum of TI (or IM plus RI) and RS or the mean shift the sector gains from regional growth and the national sectoral trend. It can be used to measure the mean strength of the sector when the national sectoral as well as regional influences are taken away from its growth.

This new extension serves two purposes. One is to overcome the asymmetry/lack-of-additivity problem, and the other is to further decompose the growth effects for regional analysis. There are now four types of regional advantages (disadvantages): national sectoral mix (*IM*), regional shift (*RS*), regional sectoral mix (*RI*) and total sectoral mix (*TI*).

The national industry mix effect (*IM*) measures the region's share of the nation's sectoral status change or the national trend for the sector. The regional shift (*RS*) measures the region's strength relative to the nation in the sector - its relative advantage. Regional industry mix (*RI*) also measures the region's strength of change relative to the nation but has netted out the regional growth effects (*RG*); it also measures the trend of specialization, the change of the location quotient for the sector or the absolute advantage of the sector. The total industry mix (*TI*) effect measures the trend of the sector's proportion change to the region -its relative importance in the region; in the case when RI and IM have opposite signs of growth, it can be used to evaluate the main source of regional change: national trend or regional dynamics.

While each of these components represents a certain specific status of its own, each combination set provides a more comprehensive picture of the sector and its growth pattern. This will give the researcher a much more enhanced and meaningful diagnostic tool in examining regional problems, particularly in identifying the strengths and weaknesses of sectors and comparing their characteristics and trends. Based on these four advantage types, there are sixteen possible combinations of regional consequences given positive regional and national growth. Some of these combinations are presented in Table 1. There are obviously sixteen reciprocal combinations based on negative regional growth effects (*RG*).

Some argued that in the traditional shift-share model, changes in the industry mix and in the national economy are not taken into account. Hence, the model does not capture the changing industrial structure of the region. This is, in fact, a weight problem, i.e., changes from beginning-of-period to end-period may have very different weights or even opposite signs for the mix and competitive effects. This is one of the most widely discussed criticisms of the model since the 60s, notably by Dunn (1960), Stilwell (1969), Chalmers (1971), Bishop and Simpson (1972).

Barff and Knight (1988) addressed this issue and extended the traditional model by fracturing the study period into two or more sub-periods to reduce the severity of changes in industrial mix on the results of the analysis. By doing so the current annual change, average annual change or sum of annual change can be calculated to obtain total national share, sectoral share and regional share across the study period:

$$TS \equiv \sum NS_{ir} + \sum IM_{ir} + \sum RS_{ir} \quad (25)$$

With its ability to adjust annually for change in industrial mix, continuously updating regional employment and using annual growth rates, the dynamic approach apparently provides a more accurate allocation of regional employment change among the three effects and allows for unusual years and years of economic transition to be identified. ANOVA-based shift-share can be adapted to the dynamic context, which adds another dimension to the analysis (Knudsen and Barff, 1991). Then:

$$e = 1/k \sum_k E_k \quad (26)$$

$$e_i - e = 1/k \sum_k E_{ik} - E_k \quad (27)$$

$$e_{ir} - e_{in} = 1/k \sum_k e_{irk} - e_{ink} \quad (28)$$

where k denotes the number of pairs of adjacent years under weighted least squares.

As discussed earlier some authors turned to other methods to improve accuracy of the shift-share model. Resulting econometric extensions of shift share analysis show another direction of development. A typical econometric model takes the following form (Berzeg, 1984):

$$y_{ijt} = a + b_i + (g_j + d_{ij}) + e_{ijt} \quad (29)$$

where

y_{ijt} is the observed growth over period t for industry i in region j. It can also be expressed as $X_{ijt}/X_{ij,t-1}$ (or its logarithm) where X is defined as the activity level,

a = the overall growth effect,

b_i = the industrial composition effect,

$g_j + d_{ij}$ = the competitiveness effect, which can be further decomposed into the regional effect (g_j) and comparative advantage term (d_{ij}),

e_{ijt} = random error.

This model corresponds to the analysis of "covariance" model proposed by Emmerson, Ramanathan and Ramm (1975). They specify:

$$ln\ (X_{ijt}/X_{ij,t-1}) = y_{ijt} = (a+b_i+g_j+d_{ij})\ t + v_{ijt} \quad (30)$$

where $E[v_{ijt}v_{mnk}] = s^2$ for $i = m, j = n, t = k;$ otherwise $E[v_{ijt}v_{mnk}] = 0$.

Table 1. Some Possible Combinations of Consequences

Combined Explanation	NI	RS	RI	TI
Single Meaning	Sectoral Advantage	Relative Advantage	Absolute Advantage	Total Sectoral Adv. (IM+RI)
Competitively growing sector in nation & region is even better off; trend of concentrating & specializing for region; the region leads the nation in their growth.	+	+	+	+
Declining sector in nation; uniquely advantaged & gaining specialization in region; positive inter-reg. shift is possible.	-	+	+	+
Booming sector in nation; but regionally disadvantaged; national trend overcomes regional disadvantages for sector; losing specialization, if any.	+	-	-	+
Competitively growing sector in nation; relatively advantaged in region; becoming more important in region but not toward specialization	+	+	-	+
Competitively growing sector in nation; disadvantage & shrinking in region; losing specialization if any; negative inter-reg. shift is possible.	+	-	-	-
Declining sector in nation; relatively advantaged in region but fails to counter nationwide decline, may not significantly change specialization status (if any).	-	+	-	-
Declining sector in nation; region is worse off and may lose sectoral specialization standing (if any) in region; the region leads the nation in their decline.	-	-	-	-
Fast declining sector in nation; enjoys some regional advantages but still affected by national sectoral decline.	-	+	+	-

Source: Qiangsheng *et al.* 1997

The Theil-Gosh model is similar to the following model of two-way layout analysis of variance (Berzeg, 1984) without interactions:

$$\ln X_{ijt} - \ln X_{ij,t-1} = y_{ijt} = a + b_i + c_j + h_{ijt} \quad (31)$$

Following Weeden (1974), Buck and Atkins (1976) go beyond the standardized shift-share models to avoid the limitations of standardization analysis. The simplest estimating equation they use is

$$g_{ir} = a_i D_i + b_r D_r + u_{ir} \quad (32)$$

where g_{ir} = industry growth in industry i in region r,

a_i, b_r = parameters obtained from the regression analysis,

D_i, D_r = Dummy variables

u_{ir} = residual random error term.

Then they put weights onto each term and define:

$\Sigma_i(W_{ir}-W_i)$ = the composition component for region r;

$b_r-\Sigma_r W_r b_r$ = the growth component for region r;

where W_{ir} = weight of industry i in region r, Wi = weight of industry i in the nation, and W_r = weight of region r in the nation. To avoid correlation of D_i and D_r, one of these dummy variables for a base region is made zero to enable X'X matrix inversion. And the following equation is used to overcome heteroscedasty:

$$g_{ir}W_{ir} = a_iD_iW_{ir} + b_rD_rW_{ir} + u_{ir}W_{ir} \tag{33}$$

Labour force participation and population growth rate differ from region to region and in most cases the labour force participation rate of the reference area is unlikely to be similar to that of the region. This issue is not included in the shift-share formulations. A region with lower population growth and labour force participation relative to the reference area will show a slower than expected growth (decline) in employment over a period of time. In their information-theoretic extension of shift-share analysis, Haynes and Machunda (1988) included labour force participation into the shift-share formulation. They proposed the integration of the information measure in the form of a Shannon or Kullback-Liebler entropy into the Esteban-Marquillas and the Arcelus extensions of shift-share model. The Esteban-Marquillas information-theoretic extension is written as:

$$\sum_{j=1}^{n} \alpha_j \Delta K_j = e_1 + e_2 + e_3 + e_4 \tag{34}$$

with:

$\alpha_j = (q_j - p_j)/\overline{K}_j$

$e_1 = \Sigma_i\Sigma_j\alpha_j K_{ij}^* \gamma_{io}$ = the reference area component

$e_2 = \Sigma_i\Sigma_j\alpha_j(K_{ij} - K_{ij}^*)\gamma_{io}$ = the modified national industry mix

$e_3 = \Sigma_i\Sigma_j\alpha_j K_{ij}^*(\gamma_{ij} - \gamma_{io})$ = the modified competitive effect

$e_4 = \Sigma_i\Sigma_j\alpha_j(K_{ij} - K_{ij}^*)(\gamma_{ij} - \gamma_{io})$ = allocation effect

where:

q_j = the share of regional employment in the national total;

p_j = the regional share of labour force in the nation;

γ_{io} = national growth rate of the employment share of sector i.

K_{ij}^* = homothetic percentage employment in industry i of region j

Here the sum of e_3 and e_4 gives the contribution of the classical competitive effect. The term (q_j-p_j) is the rate of information gain given the change in the weights of regional labour force shares.

The second information-theoretic decomposition model is based on the Arcelus extension:

$$\Sigma_j \alpha_j \Delta K_j = a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 \qquad (35)$$

where

$$a_1 = \gamma_{oo} \Sigma_i \Sigma_j \alpha_j K_{ij}^{*}$$

$$a_2 = \gamma_{oo} \Sigma_i \Sigma j\, \alpha_j (K_{ij} - K_{ij}^{*})$$

$$a_3 = \Sigma_i \Sigma_j \alpha_j K_{ij}^{*} (\gamma_{io} - \gamma_{oo})$$

$$a_4 = \Sigma_i \Sigma_j \alpha_j (K_{ij} - K_{ij}^{*})(\gamma_{io} - \gamma_{oo})$$

$$a_5 = \Sigma_i \Sigma_j \alpha_j K_{ij}^{*} (\gamma_{oj} - \gamma_{oo})$$

$$a_6 = \Sigma_i \Sigma_j \alpha_j (K_{ij} - K_{ij}^{*})(\gamma_{oj} - \gamma_{oo})$$

$$a_7 = \Sigma_i \Sigma_j \alpha_j K_{ij}^{*} [(\gamma_{ij} - \gamma_{io}) - (\gamma_{oj} - \gamma_{oo})]$$

$$a_8 = \Sigma_i \Sigma_j \alpha_j (K_{ij} - K_{ij}^{*})[(\gamma_{ij} - \gamma_{io}) - (\gamma_{oj} - \gamma_{oo})]$$

In this formulation, competitive portion of change in spatial concentration is the sum of a_5, a_6, a_7, and a_8. Such an approach brings shift-share analysis into a full information probability framework. Although this approach provides a full information equivalency, it does not alter the basic deterministic Esteban-Marquillas or Arcelus specifications. Hence, it will not be considered separately in our comparative analysis.

In a recent study, Haynes and Dinc (1997) raised the same question about the demographic structure of the region and the level of labour force participation, though they did not provide a new formulation. They argued that traditional shift-share model and its extensions in which employment is used as economic performance measure do not take into account the demographic structure of the region and the level of labour force participation in the analysis of a region's employment change. A region with a lower population growth and labour force participation relative to the reference area enjoys a slow growth (decline) in employment over a period of time, or vice versa. An increase in employment in the region may be seen as an indicator of a good economy even if this region has a high unemployment rate. This becomes much more visible in an interregional comparison. A region may increase its long-term competitiveness by increasing its output while employment is declining due to improvements in production processes, new technology, or any other components of productivity growth. Therefore, they suggested that in interregional comparisons a better measure is needed. Instead of employment, the number of establishments may be used as an alternative or supplemental measure in the shift-share model. Of course, this introduces its own set of difficulties in terms of size of firms, technology levels etc. In such cases, a look at the productivity and output change may give a better picture of the region's economy.

Recall that one of the assumptions of the shift-share model is that interregional and international trade is not included. This issue is in fact very important for regional economies in an increasingly globalizing environment. In their international shift-share model built on the Estaban-Marquillas concept of homothetic employment, Sihag and McDonough (1989) identified regional growth due to regional and national competitive advantages and regional and national specialization. They proposed a three-way classification of industries on the basis of market dominance:

(i) industries for which the international market is dominant,
(ii) industries for which the national market is dominant,
(iii) industries for which the regional market is dominant. Then the shift-share equation becomes:

$$\Delta E_{ir} = W_{ir} + WI_{ir} + C_{ir} \tag{36}$$

where W_{ir} is the world growth effect, WI_{ir} is the world industry mix effect, and C_{ir} is the competitive effect.

Incorporating Esteban-Marquillas (1972) homothetic employment concept into (26) the competitive effect (C_{ir}) may be written as

$$C_{ir} = C^T_{ir} + A^T_{ir} = (C^R_{ir} + C^N_{ir}) + (E_{ir} - E^W_{ir})(e_{ir} - e_{iw}) \tag{37}$$

where

$C^R_{ir} = E^W_{ir}(e_{ir} - e_{in})$ = regional competitive advantage relative to the nation in sector i,
$C^N_{ir} = E^W_{ir}(e_{in} - e_{iw})$ = national competitive advantage relative to the world in sector i,
$E^W_{ir} = E_{ir}(E_{iw}/E_w)$ = world homothetic employment in sector i, region, j
$A^R_{ir} = (E_{ir} - E^N_{ir})(e_{ir} - e_{iw})$ = regional specialization
$A^N_{ir} = (E^N_{ir} - E^W_{ir})(e_{ir} - e_{iw})$ = national specialization
$E^N_{ir} = E_{ir}(E_{in} - E_n)$ = national homothetic employment

World growth effect and industry mix effect may be written as:

$$W_{ir} = E^W_{ir}e_w + (E_{ir} - E^N_{ir})e_w + (E^N_{ir} - E^W_{ir})e_w \tag{38}$$

$$WI_{ir} = E^W_{ir}(e_{iw} - e_w) + (E_{ir} - E^N_{ir})(e_{iw} - e_w) + (E^N_{ir} - E^W_{ir})(e_{iw} - e_w) \tag{39}$$

where subscript w indexes world. Sihag and McDonough (1989) demonstrated that the international model possess the property of region to region additivity.

International trade has become increasingly important to the general economy as well as to regional economies and in some cases, it plays crucial role in some of these regional economies.[2] We have been witnessing the globalization of the

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2 Markusen, Noponen and Driessen (1991) and Noponen, Markusen and Driessen (1997)

world economy since World War II. In that sense, this extension of shift-share is promising, though it is difficult to test empirically. On the other hand, we know that almost 80% of world trade take place between OECD countries (The World Bank, World Development Report, 1995). If we exclude resource-based trade the share rate will undoubted go up. Assuming that these developed countries represent the world economy and most of the employment, then, we may test this as an industrial first world model. The required data set is available from international organizations such as The World Bank, OECD, and United Nations.

In a recent study, McDonough and Sihag (1991) correctly pointed out that the growth of an industry in a sub-region is likely tied to both state and national economies. In order to take account of the effect of the secondary base economy they extended the Arcelus (1984) model by selecting and including both primary and secondary-base economies in the shift-share approach. Depending on the configurations of primary and secondary-base economies, modifications of the Arcelus extension (equation 10) takes one of the following forms:

$$\Delta E_{ir} = S_{ir}^{P} + N_{ir}^{S} + SI_{ir}^{P} + NI_{ir}^{S} + R_{ir} + RI_{ir} - E_{ir}(e_{in} - e_{is}) \quad (40)$$

$$\Delta E_{ir} = S_{ir}^{P} + N_{ir}^{S} + NI_{ir}^{P} + SI_{ir}^{S} + E_{ir}[(e_{ir} - e_{in}) + (e_{s} - e_{n})] \quad (41)$$

$$\Delta E_{ir} = N_{ir}^{P} + S_{ir}^{S} + NI_{ir}^{P} + SI_{ir}^{S} + E_{ir}[(e_{ir} - e_{in}) - (e_{is} - e_{in})] \quad (42)$$

$$\Delta E_{ir} = N_{ir}^{P} + S_{ir}^{S} + SI_{ir}^{P} + NI_{ir}^{S} + E_{ir}[(e_{ir} - e_{in}) + (e_{n} - e_{s})] \quad (43)$$

where

$S_{ir}^{P} = E_{ir}e_{s}$ = state is the primary base for growth effect

$N_{ir}^{S} = E_{ir}(e_{n} - e_{s})$ = nation is the secondary base for growth effect

$N_{ir}^{P} = E_{ir}e_{n}$ = nation is the primary base for growth effect

$S_{ir}^{S} = E_{ir}(e_{s} - e_{n})$ = state is the secondary base for growth effect

$NI_{ir}^{P} = E_{ir}(e_{in} - e_{n})$ = nation is primary base for industry - mix effect.

$SI_{ir}^{P} = E_{ir}(e_{is} - e_{s})$ = state is the primary base for industry - mix effect.

$NI_{ir}^{S} = E_{ir}[(e_{in} - e_{n}) - (e_{is} - e_{s})]$ = nation is the secondary base for IM effect

$SI_{ir}^{S} = E_{ir}[(e_{is} - e_{s}) - (e_{in} - e_{n})]$ = state is the secondary base for IM effect

where subscript s denotes the state.

It should be noted that the typical interpretation of the competitive components in all of the above models implies equal productivity change over the study period across regions. However, disparities in productivity growth are very common

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developed a shift-share formulation including international trade and productivity, and applied this new formulation to U.S. census regions and metropolitan areas. This model is not discussed in this paper because there is an ongoing discussion between them and us concerning about the equations they proposed.

between the nation and the region and even more common among regions. Rigby and Anderson (1993) argued that, without properly taking productivity growth into consideration employment based shift-share models may distort the results of analysis. They pointed out that the traditional shift-share model measures the combined effects of output growth and productivity change on employment. In the traditional shift-share model, a region with above average employment growth either has a favorable industry mix or enjoys a competitive advantage over other regions. Therefore, a positive (negative) shift may result from above (below) average output growth, and below (above) average productivity gains. Unless these effects are isolated, regional performance cannot be unambiguously evaluated for regions in a country the size of the United States or Canada and over a longer period of time. In their study of employment change in the Canadian manufacturing, Rigby and Anderson (1993) introduced a productivity and output adjustment extension to the traditional shift-share model:

Q_{irt} represents output in industry i in the region r at time t, then q_{irt} represent average labour productivity in industry i in the region at time t.

$$_{irt} = Q_{irt} / E_{irt} \tag{44}$$

The change in employment anticipated in industry i in the region over the given time period, if productivity remains constant and output changes as observed, is

$$A_{ir} = (Q_{ir\,(t+1)} - Q_{irt}) / q_{irt} \tag{45}$$

The potential change in employment in industry i in the region resulting from variations in productivity with output constant is

$$B_{ir} = (Q_{ir\,(t+1)} / q_{ir\,(t+1)}) - (Q_{ir\,(t+1)} / q_{irt}) \qquad 6)$$

In relative terms $a_{ir} = A_{ir} / E_{ir}$ represents the rate of employment change in industry i in the region resulting from variations in output over the given time period with productivity constant; $b_{ir} = B_{ir} / E_{ir}$ represents the rate of employment change in industry i in the region resulting from variations in productivity over the given time period with output constant. Then, $g_{ir} = a_{ir} + b_{ir}$ and these rates of change may be defined at the level of industry, the region or the nation.

Rigby and Andersen (1993) use these equations to incorporate the separate effects of productivity and output changes in the basic shift-share model.

$$TS \equiv TS(a) + TS(b) = \sum E_{ir} [(a_{ir} - a_n) + (b_{ir} - b_n)] \tag{47}$$

$$PS \equiv PS(a) + PS(b) = \sum E_{ir} [(a_{in} - a_n) + (b_{in} - b_n)] \tag{48}$$

$$DS \equiv DS(a) + DS(b) = \sum E_{ir} [(a_{ir} - a_{in}) + (b_{ir} - b_{in})] \tag{49}$$

Even though, the work by Rigby and Anderson (1993) may provide valuable information, Haynes and Dinc (1997) argue that Rigby and Anderson (1993) ignore the non-labour factors' contribution to productivity, and hence its impact on employment change. This may cause some misleading conclusions because any kind of change in factors of production may happen over the study period in a region or regions under consideration. A lagging region may increase its output by investing heavily in capital stocks or by investing in education and training programs and as a result, improving labour productivity. In that case, labour is considered as the same in terms of skills and productivity in both regions. In addition, the industry-mix of a region possesses an important role in regional productivity. A region with capital intensive industry-mix such as chemicals, petroleum or tobacco sectors will enjoy higher labour productivity than a region with labour intensive industry-mix.

To improve the Rigby and Anderson extension they separate labor's and capital's contribution to productivity. By following Kendrick (1961, 1973, 1983, 1984), they employed the total factor productivity (*TFP*) approach to separate labour and capital (or non-labour) productivity. In this approach, productivity is defined as the relationship between output of goods and services and the inputs of resources and is usually expressed in ratio form, the ratio of aggregate output to the sum of inputs. Outputs are weighted by their costs per unit in constant prices. The inputs are combined in terms of their share in total costs in constant prices. Hence, to maintain the simplicity of the shift-share model they employed this method.

$$TFP = Y / [\alpha L + (1-\alpha) K + ...] \tag{50}$$

where Y is the total output, L and K are the quantities of labour and capital inputs, respectively, and α is the weight of inputs and derived as the estimated shares of factor payments in national (regional) income. At the sectoral level total factor productivity can be calculated as

$$TFP_i = Y_i / [\alpha_i L_i + (1-\alpha_i) K_i + ...] \tag{51}$$

where subscript i represents ith sector under consideration.

Equation (40) can be rewritten as:

$$1 / TFP \equiv [\alpha L + (1 - \alpha)K] / Y \tag{52}$$

$$1 / TFP \equiv (\alpha L /Y) + [(1 - \alpha)K /Y] \tag{53}$$

$$1 / TFP \equiv 1/ TFP_L + 1/ TFP_K \tag{54}$$

$$1/TFP_L \equiv \alpha L /Y \quad and \quad 1/TFP_K \equiv (1 - \alpha)K /Y$$

where TFP_L and TFP_K are labour and capital productivity, respectively.

By following equations (44) through (49) they rewrite the shift-share equations to investigate employment change as:

$$TS_L \equiv NS_L + PS_L + DSL \tag{55}$$

$$NS_L \equiv NS(a_L) + NS(b_L) = \sum E_{ir} (a_{nL} + b_{nL}) \tag{56}$$

$$PS_L \equiv PS(a_L) + PS(b_L) = \sum E_{ir} [(a_{inL}-a_{nL}) + (b_{inL}-b_{nL})] \tag{57}$$

$$DS_L \equiv DS(a_L) + DS(b_L) = \sum E_{ir} [(a_{irL}-a_{inL}) +(b_{irL}-b_{inL})] \tag{58}$$

to investigate capital change as:

$$TS_K \equiv NS_K + PS_K + DS_K \tag{59}$$

$$NS_K \equiv NS(a_K) + NS(b_K) = \sum K_{ir} (a_{nK} + b_{nK}) \tag{60}$$

$$PS_K \equiv PS(a_K) + PS(b_K) = \sum K_{ir} [(a_{inK}-a_{nK}) + (b_{inK}-b_{nK})] \quad (61)$$

$$DS_K \equiv DS(a_K)+DS(b_K) = \sum K_{ir} [(a_{irK}-a_{inK})+(b_{irK}-b_{irK})] \quad (62)$$

In the case of the lack of reliable capital stock data at state and sector level to determine the contribution of other factors - namely capital, technology, infrastructure and raw material - to total productivity, and hence its impact on employment change they let ΔE be the actual employment change over time in the region, TS_L is the total shift in labour (employment change) in the region resulting from the change in labour productivity and output. Then the difference between actual change and total shift will give the employment change resulting from the other production factors' contribution to total factor productivity, ΔE_{NL}. This can be formulated as:

$$\Delta E_{NL} = \Delta E - TS_L \quad (63)$$

The Haynes-Dinc extension can also be seen as an answer to the technology related assumption of the classical shift-share model. Assuming that the technology change is embedded in non-labour factors (i.e., new capital investments), then it is possible to assess the role of technology in employment change. For example, a region with higher ΔE_{NL} implies that this region has a relatively better technology or infrastructure.

The Rigby-Anderson and Haynes-Dinc models could also be seen as a response to the criticisms that the technique provides no information on the capacity of a region to retain growing industries or on how to attract them in the first place (Richardson, 1978). Although in most cases, shift-share explains what has happened but not why it has happened both models could address why the growth has happened by providing information about output growth, productivity change and non-labour factors' effect.

4. DATA AND APPLICATION

For the purpose of comparing the models articulated here, we employed Fairfax County (including Fairfax City and Falls Church City)[3] and Virginia using annual employment data from 1972 to 1988. For the McDonough and Sihag multi-base model, in addition to the Fairfax and Virginia database we use US annual employment data. Following Rigby and Anderson, the Haynes and Dinc model incorporates employment data on wages and output. The wages and employment data come from the Bureau of Economic Analysis (BEA), output data are from the Fairfax Regional Econometric Input Output Model of the Center for Regional Analysis, The Institute of Public Policy at George Mason University. These annual

[3] Fairfax City and the City of Falls Church are independent entities within Fairfax County. For the purpose of this analysis, data for these two small cities (together they account for less than 5% of the total county population) has been added to that of Fairfax County.

Table 2. Decomposition Structure of Different Models

	National Share		Industry Mix		Regional Share			
Classical	NS		IM		RS			
Esteban-Marquillas	NS		IM		RS	AE		
Arcelus	NS		IM		RG	RI		
Qiangsheng	NS		IM		RG	RI	RS	TI
Mcdonoguh-Sihag	Sp	Ns	NIp	SIs	RS			
Rigby-Anderson	NS(a)	NS(b)	IM(a)	IM(b)	RS(a)	RS(b)		
Haynes-Dinc	NS(a)	NS(b)	IM(a)	IM(b)	RS(a)	RS(b)	O.Fact.	
Haynes-Machunda	NSe1		IMe2		RGe3	RIe4		

employment, wages and output data are aggregated by twelve region specific major industry groups: agriculture products; agricultural services; mining;construction; non-durable manufacturing; durable manufacturing; transportation and transportation services; communication; utilities; trade; finance, insurance and real estate; and services.

Nine of the models discussed earlier are compared and evaluated, though two of them are not empirically tested. In all models tested we used the dynamic approach of Barff and Knight (1988).

5. ANALYSIS OF RESULTS

Between 1972 and 1988 Fairfax county increased its total employment by 315,494. With the exception of agricultural products sector all sectors in Fairfax County increased their employment during the study period. Among them theservices and trade sector are the fastest growing sectors with an increase in employment by 144,467 and 75,273 respectively. 85% of the increase in employment (268,266) came from service-related sectors and 8.8% from the construction sector (27,823). These results show that the economy of Fairfax County increasingly became a service-oriented economy. The growth in the construction sector (fourth fastest growing sector) may in fact be interpreted as an indicator of a healthy economy because it is assumed that construction is in general locally oriented sector. The only declining sector in the county is the agricultural products sector, which is negligible.

In five of the seven models tested empirically, the employment change or total shift is identical to the actual absolute change. However, two of them, McDonough and Sihag (1991), and Haynes and Dinc (1997), show differences in total shift because of different orientation of models. Before further discussion, it should be noted that the main differences among these models lay in the allocation of employment change. Since, the comparison of these models is based on these allocation effects not on the actual (absolute) numbers the allocation framework needs to be considered.

Table 2 compares the decomposition structure of the tested models and aggregated results of these models are presented in Table 3. A sector by sector analysis and comparison is presented in Appendix A. By comparison, we do not mean the application of any significance testing or related statistical tests, instead we mean how these models are allocating sources of employment change. Table 3 reveals that the classical shift-share model attributes 42% of this growth to the state (reference area) growth effect, 11% to the industry mix effect and the remaining 47% to the regional competitiveness effect. Meaning that Fairfax County has some major regional advantages relative to the state.

Based on this model's findings Fairfax County has regional advantages in nine sectors out of twelve in which employment growth resulting from regional advantages is larger than the growth attributable to other components. However, six of the twelve major sectors we have investigated in Fairfax County are nationally declining sectors (agriculture products, mining, non-durable and durable manufacturing, transportation services and communication). The national share is positive in all sectors and had a significant impact on employment growth. The county's strong employment growth points are the services, trade and construction sectors.

The Esteban-Marquillas model shows that regional growth share for Fairfax county would have been 57% if the location quotient had equaled one for the region (sector), but this region has lost 18.6% of its employment because the location quotient is different than one. This means that the county did not specialize in the same industries as the state. This loss shows up in the allocation effect, *Ae*. In this model, durable and non-durable manufacturing sectors in Fairfax County are the least favorable sectors relative to the state and followed by the transportation services and agriculture products sectors because their regional shares were eroded by the allocation effect most. This model indicates that Fairfax County has, in fact, some regional advantages in all these sector with the exception of Utilities, but in seven of them it did not specialize and this reduced Fairfax County's potential growth.

The Arcelus model, on the other hand, allocates the employment change in a similar but slightly different way. In that model, Fairfax economy has grown faster than the state economy and had employment growth based on its advantages, 57.6%. However, some sectors in Fairfax did not grow as fast as their state counterparts and it lost 19% of its potential growth. Although Fairfax had regional growth in all sectors, its employment growth was slower than the state's in seven sectors. The mining, durable and non-durable manufacturing, transportation services and communication services grew faster than their state counterparts.

In the Qiangsheng model, total industry mix effect (TI) is negligible, and the driving factors in the region are due to its internal dynamics, represented as a

57.6% regional growth effect. This model can be best appreciated by looking at the possible combinations of the sub-components of the regional share component (see for more detailed presentation Qiangsheng *et al.*, 1997). In Fairfax County, five sectors (the agriculture services, construction, trade, FIRE and services) had employment growth statewide during the study period, and were relatively advantaged and becoming more important in the county. The mining, durable manufacturing and transportation services were declining in the state and enjoyed some advantages in the county but affected by the statewide sectoral decline. The non-durable manufacturing and communication sectors were among the declining sectors in the state but these sectors were uniquely advantaged in the county and gaining specialization.

The Esteban-Marquillas, Arcelus and Qiansheng models are quite similar. They focus on the regional shift and decompose it to obtain more insights about the sources of regional advantages or disadvantages. All three models suggest that Fairfax county has some locational advantages.

Four different variations of the shift-share model are proposed in the McDonough and Sihag extension depending on the selection of primary and secondary base economies for the region for both growth and industry mix effects. In this paper, for illustration purpose we assumed that the state is the primary base for the growth effect, while the nation is the primary base economy for industry mix effect. According to this model employment in Fairfax county should have grown by 359,867 instead of 315,494. An analytic selection of primary and secondary base economies through a correlation analysis rather than assumptions could produce better and more interpretable results. Therefore this particular model should be interpreted with caution. However, the findings of this model show similar trends for sectors of the county as in the earlier models, i.e., the services, trade and the construction sectors are the fastest growing sectors and Fairfax county has regional advantages in these sectors.

The Rigby-Anderson and Haynes-Dinc models are similar in nature, and these models could be better understood in a comparative framework. Both models investigate the impact of productivity and output change on employment. However, the Rigby and Anderson model attributes all changes in employment to the productivity gain (loss) and output growth (decline). The Rigby-Anderson model links employment growth to output growth. If productivity in Fairfax county has remained constant the employment change would have been 442,472 instead of 315,494, but because of productivity gain Fairfax has lost 126,978 jobs during the investigation period, and ended up with a real employment growth of 315,494 (442,472 - 126,978).

The Haynes and Dinc model also suggests that employment change in Fairfax county is driven by a mix of output growth and productivity. However, this model also takes into account the non-labour factors' contribution such as new entries and capital investments. The results of the Haynes and Dinc model show that labour productivity gain has caused a decline in employment by 48,212 but this is much smaller than the Rigby-Anderson model. Similarly, employment growth due to output increases is much smaller in this model. The difference between these two models is a result of non-labour factors contribution to productivity and employment growth. If there had been no impact of non-labour factors in the county total employment change would have been 134,258 instead of 315,494. In this model 57.4% of employment growth has resulted from new capital investments or from some other factors (i.e., non-labour investments, infrastructure).

Investigation of the regional shift components of both models reveals that the Rigby-Anderson model suggests that seven sectors in the county have improved their productivity and as a result have lost employment. On the other hand, the Haynes and Dinc model shows that only four sectors improved their productivity and lost employment (the utilities sector's productivity gain is negligible in this model) and the magnitude of losses is much smaller than the Rigby-Anderson model. For example, according to the Rigby-Anderson model the FIRE sector was the most productive sector during this period and caused a substantial employment decline. However, employment growth due to output increases in this sector outpaced the decline from productivity. The Haynes-Dinc model, on the contrary, indicates that this sector in fact worsened its productivity. In both models, the transportation service, mining and agriculture products sectors performed poorly in terms of productivity improvement and this saved the county from heavy employment losses in these sectors.

The two Haynes and Machunda extensions, are not tested because of different labour force data requirements. In these models, employment by residency data is used, but the data set at hand did not include it. The use of employment by place of work data could give distorted results because employment in the region could be higher than the labour force (this is most likely the case in Fairfax County) because of commuting workers from adjacent regions (counties). Finally these models are not so much an extension or reformulation of the original Esteban-Marquilals and Arcelus models as they are a re-calibration of model metrics. The examination of these models may provide insights more tuned to local policy makers because of its inclusion of residential labour force making this model more community rather than regionally oriented.

6. CONCLUSION

In this paper, we have compared different shift-share formulations and illustrated this comparison by applying a common data set to all models under consideration. Our primary purpose was not to provide some policy recommendation to Fairfax County policymakers however, the analysis showed that the economy of Fairfax county is becoming more and more service oriented. This is at least partly a result of its very close location to Nation's capital (Greater Washington, D.C. Metropolitan Area). Further, the increasing growth in high-tech related sectors often reflected in the service sector in the region may have contributed to its healthy economic base.

Our analysis showed that shift-share is a very useful regional analysis tool and depending on the researcher's purpose it can provide various kinds of information about the regional economy by employing one of the various extension noted above. For example, for general differential effects the classical model seems most appropriate; for regional disaggregation Arcelus' model is particularly valuable; for international and higher level regional effects one of the McDonough and Sihag models seem to fit best; for controlling interweaving effects the Qiansheng model is insightful; for productivity and output assessment the Rigby-Anderson model as modified by Haynes and Dinc model seems most appropriate.

The criticisms of the classical shift-share model have helped with its improvement, and the model through a variety of extensions and modifications has become much more robust, more flexible and useful. There is a saying in Turkish which we think applies here. It goes something like this "if a tree has good fruit on it everyone wants to throw rocks at it, fortunately, its beneficiaries water it, fertilize it and take care of it, so that it may give even better fruit in the future." The shift-share model deserves our continued care, pruning and grafting to ensure its future effectiveness in regional economic analysis.

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APPENDIX A: Comparison of Shift-Share Models

Classical Shift-Share Model

	NS	IM	RS	Total Shift	Employment Change
AGRPROD	219	-361	140	-2	-2
AGRSERV	1060	797	1362	3219	3219
MINING	350	-502	781	629	629
CONSTR	12730	4581	10512	27823	27823
NDURMFG	2549	-2425	7279	7403	7403
DURMFG	3879	-2290	6566	8155	8155
TRANSPSER	2414	-993	3680	5101	5101
COMM	3560	-147	7400	10812	10812
UTILITIES	1103	4	-98	1008	1008
TRADE	35809	670	38794	75273	75273
FIRE	19940	7369	4296	31605	31605
SERVICES	50196	28622	65649	144467	144467
TOTAL	133807	35324	146363	315494	315494

Esteban-Marquillas Model

	NS	IM	RS	Ae	Total Shift	Employment Change
AGRPROD	219	-361	3398	-3258	-2	-2
AGRSERV	1060	797	1429	-66	3219	3219
MINING	350	-502	3852	-3071	629	629
CONSTR	12730	4581	8547	1966	27823	27823
NDURMFG	2549	-2425	47131	-39852	7403	7403
DURMFG	3879	-2290	21701	-15135	8155	8155
TRANSPSER	2414	-993	7738	-4058	5101	5101
COMM	3560	-147	5342	2058	10812	10812
UTILITIES	1103	4	-36	-62	1008	1008
TRADE	35809	670	31906	6888	75273	75273
FIRE	19940	7369	1829	2467	31605	31605
SERVICES	50196	28622	47092	18557	144467	144467
TOTAL	133807	35324	179928	-33565	315494	315494

Arcelus Model

	NS	IM	RG	RI	Total Shift	Employment Change
AGRPROD	219	-361	318	-178	-2	-2
AGRSERV	1060	797	1395	-33	3219	3219
MINING	350	-502	453	328	629	629
CONSTR	12730	4581	17784	-7272	27823	27823
NDURMFG	2549	-2425	3248	4032	7403	7403
DURMFG	3879	-2290	5081	1485	8155	8155
TRANSPSER	2414	-993	3252	428	5101	5101
COMM	3560	-147	4452	2948	10812	10812
UTILITIES	1103	4	1581	-1679	1008	1008
TRADE	35809	670	49487	-10693	75273	75273
FIRE	19940	7369	28175	-23878	31605	31605
SERVICES	50196	28622	66461	-812	144467	144467
TOTAL	133807	35324	181687	-35324	315494	315494

Qiansheng Model								
	NS	IM	RS	RI	TI	RG	Total Shift NS+TI+RG	Employment Change
AGRPROD	219	-361	140	-178	-539	318	-2	-2
AGRSERV	1060	797	1362	-33	764	1395	3219	3219
MINING	350	-502	781	328	-174	453	629	629
CONSTR	12730	4581	10512	-7272	-2691	17784	27823	27823
NDURMFG	2549	-2425	7279	4032	1607	3248	7403	7403
DURMFG	3879	-2290	6566	1485	-805	5081	8155	8155
TRANSPSER	2414	-993	3680	428	-565	3252	5101	5101
COMM	3560	-147	7400	2948	2801	4452	10812	10812
UTILITIES	1103	4	-98	-1679	-1675	1581	1008	1008
TRADE	35809	670	38794	-10693	-10023	49487	75273	75273
FIRE	19940	7369	4296	-23878	-16509	28175	31605	31605
SERVICES	50196	28622	65649	-812	27810	66461	144467	144467
TOTAL	133807	35324	146363	-35324	0	181687	315494	315494

McDonough and Sihag Model (State is primary base for growth, nation is primary for industry mix effect)							
	Sp	Ns	NIp	SIs	RI	Total Shift	Employment Change
AGRPROD	219	-68	-216	-145	131	-79	-2
AGRSERV	1060	-333	943	-146	1882	3405	3219
MINING	350	-118	-251	-251	767	496	629
CONSTR	12730	-3762	1591	2990	21025	34574	27823
NDURMFG	2549	-844	-1630	-795	8172	7451	7403
DURMFG	3879	-1242	-2451	161	9211	9559	8155
TRANSPSER	2414	-745	56	-1049	4121	4797	5101
COMM	3560	-1213	-2264	2117	11942	14142	10812
UTILITIES	1103	-334	-156	160	730	1502	1008
TRADE	35809	-10848	3118	-2448	58043	83673	75273
FIRE	19940	-5997	3721	3648	19939	41251	31605
SERVICES	50196	-15457	29452	-830	95734	159095	144467
TOTAL	133807	-40962	31912	3412	231698	359867	315494

Rigby and Anderson Model											
	NSa	NSb	IMa	IMb	RSa	RSb	Total a	Total b	Total Shift	Employment Change	Other Factors
AGRPROD	86	-12	339	-517	-549	651	-124	122	-2	-2	0
AGRSERV	470	-141	518	611	1814	-52	2802	417	3219	3219	0
MINING	145	-28	-228	18	-89	811	-172	801	629	629	0
CONSTR	5529	-1592	-145	1124	31694	-8787	37078	-9255	27823	27823	0
NDURMFG	1107	-289	-738	-217	7522	17	7891	-488	7403	7403	0
DURMFG	1716	-509	566	-1832	12808	-4594	15090	-6934	8155	8155	0
TRANSPSER	1067	-318	192	-998	4268	891	5527	-425	5101	5101	0
COMM	1503	-319	1339	-2269	12586	-2027	15428	-4616	10812	10812	0
UTILITIES	464	-115	-349	276	561	172	675	333	1008	1008	0
TRADE	15519	-4353	8929	-8213	80980	-17590	105429	-30156	75273	75273	0
FIRE	8339	-1947	40137	-41108	58958	-32774	107434	-75829	31605	31605	0
SERVICES	22196	-6539	23572	6359	99648	-768	145416	-949	144467	144467	0
TOTAL	58139	-16162	74132	-46765	310202	-64051	442472	-126978	315494	315494	0

Haynes and Dinc Model											
	NSa	NSb	IMa	IMb	RSa	RSb	Total a	Total b	Total Shift	Employment Change	Other Factors
AGRPROD	86	-12	339	-517	-430	457	-5	-72	-77	-2	75
AGRSERV	470	-141	518	611	790	42	1777	511	2289	3219	930
MINING	145	-28	-228	18	-25	255	-108	245	137	629	492
CONSTR	5529	-1592	-145	1124	5074	-2008	10458	-2476	7982	27823	19841
NDURMFG	1107	-289	-738	-217	1529	347	1898	-159	1739	7403	5663
DURMFG	1716	-509	566	-1832	3310	-1029	5592	-3370	2222	8155	5933
TRANSPSER	1067	-318	192	-998	1332	417	2591	-899	1692	5101	3410
COMM	1503	-319	1339	-2269	3077	-286	5919	-2874	3045	10812	7767
UTILITIES	464	-115	-349	276	-15	-1	99	161	260	1008	748
TRADE	15519	-4353	8929	-8213	24891	-6865	49339	-19431	29908	75273	45365
FIRE	8339	-1947	40137	-41108	-17518	16334	30959	-26722	4237	31605	27368
SERVICES	22196	-6539	23572	6359	28183	7053	73951	6873	80824	144467	63643
TOTAL	58139	-16162	74132	-46765	50199	14716	182470	-48212	134258	315494	181236