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Research Article

ECONOMIC DEVELOPMENT MODEL USING PRODUCTIVITY AND TECHNICAL CHANGES: MODIFIED GENERAL INDEX (MGI), GENERALIZED MODIFIED GENERAL INDEX (GMGI) AND GENERAL TIME TREND INDEX (GTTI)

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ABSTRACT
The important issue here is how the production based on modern technology can be expanded. This depends on factors which influence the modern production process. In this paper, we present new indices for estimating technical change, return to scale, and TFP growth. These indices, Modified General Index (MGI), Generalized Modified General Index (GMGI) and General Time Trend index (GTTI), are a generalization of the General Index. The results of the study suggest that for the estimation of technical change, return to scale, and TFP growth, the MGI method is appropriate when we have time series data or panel data with limited cross section data. When there is a need to compare irregular periods of time (for evaluation plan or policies), we suggest the GMGI method and when we have time series data or panel data with limited cross section data, and a trend in every period, we propose the GTTI method. Besides These methods, The most important factor involved in the development program success is to adjust the program projects with natural, social and economic conditions of that region.

Keywords*: Productivity, Technical Change, production technology, Generalized Modified General Index, Economic Development, and General Time Trend index*

INTRODUCTION
Productivity measurement provides a key indicator for evaluating the performance of an economic activity, and helps policy makers design optimal solutions for enhancing productivity (Kavoosi*et al*, 2010).The importance of this marker has incited economist to present and test approaches that can determine technical change, return to scale, and TFP growth many examples of which are found in literature (such as Diewert. 1976, Baltagi and Griffin. 1988, Capalbo, 1988, Baltagi*et al*. 1995, Kumbhakar and Heshmati. 1996, Kumbhakar*et al*. 2000). Diewert (1981) categorized approaches to measuring technical change into the four groups that included econometric estimation, Divisia indices, exact index numbers and nonparametric methods using linear programs (Baltagi and Griffin, 1988). The econometric approaches,which usecost, production and new profit functions (such as kumbhakar, 2002) can estimate technical change, returnto scale and TFP growth. In literature, there are two approaches to the estimation of technical change, return to scale and TFP growth by the cost function; the Time Trend and the General Index. General Index was proposed by Baltagi and Griffin (1988). Their procedure gives a measure of TFP growth that is generally found to be close to the Divisia index (Kumbhakar, 2004). Similar to the general index approach Kumbhakar (2004) later inputs the Time Trend index in the cost function.

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In this paper, we first review Kumbhakar (2004)'s two approaches: the Time Trend and the General index. Then because of the shortcomings of Kumbhakar (2004)'s General Index, we proposed three new indices; the Modified General Index, the Generalized Modified General Index and the General Time Trend Index. We estimate TFP growth using these four approaches and compare it to the Divisia Index.

MATERIALS AND METHODS

If the production process (such as Kumbhakar, 2004) is a dual Translog cost function because it imposes minimum a priori restrictions on the underlying production technology and approximates a wide variety of functional forms (Kumbhakar, 2004). We can compare the five approaches together.

1. The Time Trend (TT) Model (Kumbhakar, 2004)

Assuming that panel data is available, the single output Translog cost function can be written as

$$\begin{aligned}\text{Ln}\, C_{it} &= \beta_0 + \sum_j \beta_j \,\text{Ln}\, P_{jit} + \beta_y \,\text{Ln}\, Y_{it} + \beta_t t \\ &+ 0.5\left[\sum_j \sum_j \beta_{jk} \,\text{Ln}\, P_{jit} \,\text{Ln}\, P_{kit} + \beta_{yy} (\text{Ln}\, Y_{it})^2 + \beta_{tt}(t)^2\right] \\ &+ \sum_j \beta_{jy} \,\text{Ln}\, P_{jit} \,\text{Ln}\, Y_{it} + \sum_j \beta_{jt} \,\text{Ln}\, P_{jit} t + \beta_{yt} \,\text{Ln}\, Y_{it} t.\end{aligned} \tag{1}$$

Where C is total cost, $P_j$is the j_{th} input price and Y is output. The subscript i and t denote province and time respectively. Regularity condition can be imposed by $\beta_{jk} = \beta_{kj}$, $\sum_j \beta_j = 1, \sum_j \beta_{jk} = 0\ \forall k$, $\sum_j \beta_{jy} = 0$ and $\sum_j \beta_{jt} = 0$. The time variable t in the cost function represents shifts in the production technology. From the above cost function, one can compute technical change (TC/TT) as follows:

$$\text{TC/TT}_{it} = \partial \text{Ln}\, C_{it} / \partial t = -\left[\beta_t + \beta_{tt} t + \sum_j \beta_{jt} \,\text{Ln}\, P_{jit} + \beta_{yt} \,\text{Ln}\, Y_{it}\right] \tag{2}$$

Returns to scale can be measured from

$$\text{RTS/TT}_{it} = 1/(\partial \text{Ln}\, C_{it} / \partial Ln Y_{it}) = 1/(\beta_y + \beta_{yy} \,\text{Ln}\, Y_{it} + \sum_j \beta_{jy} \,\text{Ln}\, P_{jit} + \beta_{yt} t) \tag{3}$$

Finally, using the definition of the TFP growth (the Divisia index) it can be shown that

$$\dot{\text{TFP}} = \dot{Y} - \sum_j S_j \dot{x}_j = \text{TC/TT} + \dot{Y}(1 - (1/\text{RTS/TT})) \tag{4}$$

Where S_j is the cost share of the j_{th} input. TFP growth is thus decomposed into a technical change (TC) and a Return to scale (RTS) component. These components are calculated using the estimated parameters of the cost function and data.

2. The General Index (GI) Model (Kumbhakar, 2004)

The Translog cost function incorporating the general index can be written as

$$\begin{aligned}\text{Ln}\, C_{it} &= \beta_0 + \sum_j \beta_j \,\text{Ln}\, P_{jit} + \beta_y \,\text{Ln}\, Y_{it} + \beta_a A(t) \\ &+ 0.5\left[\sum_j \sum_j \beta_{jk} \,\text{Ln}\, P_{jit} \,\text{Ln}\, P_{kit} + \beta_{yy} (\text{Ln}\, Y_{it})^2 + \beta_{aa} (A(t))^2\right] \\ &+ \sum_j \beta_{jy} \,\text{Ln}\, P_{jit} \,\text{Ln}\, Y_{it} + \sum_j \beta_{jt} \,\text{Ln}\, P_{jit} A(t) + \beta_{yt} \,\text{Ln}\, Y_{it}\, A(t).\end{aligned} \tag{5}$$

Where C is total cost, $P_j$is the j_{th} input price and Y is output. The subscript i and t denote province and time respectively. Regularity condition can be imposed by $\beta_{jk} = \beta_{kj}$, $\sum_j \beta_j = 1, \sum_j \beta_{jk} = 0\ \forall k$, $\sum_j \beta_{jy} = 0$ and $\sum_j \beta_{jt} = 0$. The General Index variable $A(t)$ in the cost function represents shifts in the production technology. Baltagi and Griffin (1988) showed that $A(t) = \sum_{i=2}^{t} \lambda_i L_i$. Where, L_t s are Dummy Variables for Years and λ s must be specified.

Analogous to the time trend model, technical change in the general index model (TC/GI) is defined as

$$\begin{aligned}\text{TC/GI}_{it} &= -\left[A(t) - A(t-1)\right] \\ &\left[\beta_a + 0.5\beta_{aa}\left[A(t) - A(t-1)\right] + \sum_j \beta_{jt} \,\text{Ln}\, P_{jit} + \beta_{yt} \,\text{Ln}\, Y_{it}\right]\end{aligned} \tag{6}$$

Finally, returns to scale is obtained from

$$\text{RTS/GI}_{it} = 1/(\partial \text{Ln}\, C_{it} / \partial\, \text{Ln} Y_{it}) = 1/(\beta_y + \beta_{yy} \,\text{Ln}\, Y_{it} + \sum_j \beta_{jy} \,\text{Ln}\, P_{jit} + \beta_{yt} A(t)) \tag{7}$$

and TFP growth from

$$\dot{\text{TFP}} = Y - \sum_j S_j \dot{x}_j = \text{TC/GI} + \dot{Y}(1-(1/\text{RTS/GI})) \tag{8}$$

3. The Modified General Index (MGI) model

In order to use the General Index, We need Panel data. That is, the General Index approach can use only for panel data. Using the General Index for time series data can create problems related to the degree of freedom. This problem can be solved by the MGI. In other words, we can use the MGI for both panel and time series data. The Translog cost function incorporating the general index can be written as

$$\begin{aligned}\text{Ln}\, C_{it} &= \beta_0 + \sum_j \beta_j \,\text{Ln}\, P_{jit} + \beta_y \,\text{Ln}\, Y_{it} + \beta_a A(th) \\ &+ 0.5\left[\sum_j \sum_j \beta_{jk} \,\text{Ln}\, P_{jit} \,\text{Ln}\, P_{kit} + \beta_{yy} (\text{Ln}\, Y_{it})^2 + \beta_{aa} (A(th))^2\right] \\ &+ \sum_j \beta_{jy} \,\text{Ln}\, P_{jit} \,\text{Ln}\, Y_{it} + \sum_j \beta_{jt} \,\text{Ln}\, P_{jit} A(th) + \beta_{yt} \,\text{Ln}\, Y_{it}\, A(th).\end{aligned} \tag{9}$$

Where C is total cost, $P_j$is the j_{th} input price and Y is output. The subscript i and t denote province and time respectively. Regularity condition can be imposed by $\beta_{jk} = \beta_{kj}$, $\sum_j \beta_j = 1, \sum_j \beta_{jk} = 0\ \forall k$, $\sum_j \beta_{jy} = 0$ and $\sum_j \beta_{jt} = 0$. $A(th)$ represents the production technology. In this approach $A(th)$ is defined as $A(th)=\sum_{h=i}\lambda_h L_h$. Where, L_hs are Dummy Variables for Periods of time as expressed as time intervals. For example, L_h may be a dummy variable indicating two, three or more years (*i* is the length of time and not necessarily a year). Choice of this period is one of our problems. If a firm or a country has regular plans or policies for the development of industries or an economic sector (such as the Agriculture sector), we can determine the preferred time period for the fulfillment of these plans or policies. We can *h* test using the LR test. If *h* is small, then the degree of freedom for the problem is higher. If *h* =1, the MGI is similar to the GI.

Analogous to the GI, technical change in the MGI model (TC/MGI) is defined as

$$\text{TC/MGI}_{it} = -\left[A(th)-A(th-h)\right]$$
$$\left[\beta_a + 0.5\beta_{aa}\left[A(th)-A(th-h)\right] + \sum_j \beta_{jt}\,\text{Ln}\,P_{jit} + \beta_{yt}\,\text{Ln}\,Y_{it}\right] \quad (10)$$

Finally, returns to scale is obtained from

$$\text{RTS/MGI}_{it} = 1/(\partial \text{Ln}\,C_{it}/\partial \text{Ln}\,Y_{it}) = 1/(\beta_y + \beta_{yy}\,\text{Ln}\,Y_{it} + \sum_j \beta_{jy}\,\text{Ln}\,P_{jit} + \beta_{yt}\,A(th)) \quad (11)$$

and TFP growth from

$$\dot{\text{TFP}} = Y - \sum_j S_j \dot{x}_j = \text{TC/GI} + \dot{Y}(1-(1/\text{RTS/MGI})) \quad (12)$$

4. The Generalized Modified General Index (GMGI) model

In order to use the Modified General Index, we need to have regular periods of time. Regular time periods occur in firms or countries that have regular development plans. Sometimes however, we encounter irregular plans or no planning at all. In such cases, different time periods with unequal intervals need to be compared together. For example, we want to compare technical changes in the drought period of 2000-2002 (3 years) with the drought period of 2003-2008 (5 years)In such cases we cannot use the MGI. GMGI however can solve this problem. Through this approach, $A(th)$ can be defined for irregular periods of time. For example, $A(t)=\lambda_2 L_{6\text{-}10}+\lambda_3 L_{11\text{-}12}+\cdots+\lambda_t L_{t-h-T}$. This means that a different dummy variable is chosen for years 6 to 10, and another dummy variable for years 11-12. We can also compare technical change, return to scale and TFP growth of years 6-10 (5Yeras) with years 11-12 (2 years). If time periods are equal however, the MGI will be equal to the GMGI.

5. *The General Time Trend Index (GTTI) model*

In order to use the MGI and the GMGI, we need technology with a constant trend in the considered period of time. This constant trend however is not usually applicable in the case of many firms or countries. For example, when comparing the technical change of the drought period of 2000-2002 (3 years) with the drought period of 2003-2008 (5years), the first and last years of the two periods do not correspond. That is, the trend differs from one period to another. As a response to this problem, we suggest the GTTI. The Translog cost function incorporating the GTTI can be written as

$$\begin{aligned}\text{Ln}\, C_{it} &= \beta_0 + \sum_j \beta_j \,\text{Ln}\, P_{jit} + \beta_y \,\text{Ln}\, Y_{it} + \beta_a A(tt) \\ &+ 0.5\left[\sum_j\sum_j \beta_{jk}\,\text{Ln}\, P_{jit}\,\text{Ln}\, P_{kit} + \beta_{yy}(\text{Ln}\, Y_{it})^2 + \beta_{aa}(A(tt))^2\right] \\ &+ \sum_j \beta_{jy}\,\text{Ln}\, P_{jit}\,\text{Ln}\, Y_{it} + \sum_j \beta_{jt}\,\text{Ln}\, P_{jit} A(tt) + \beta_{yt}\,\text{Ln}\, Y_{it}\, A(tt).\end{aligned} \tag{13}$$

Where C is total cost, $P_j$is the j_{th} input price and Y is output. The subscript i and t denote province and time, respectively. Regularity condition can be imposed by $\beta_{jk} = \beta_{kj}$, $\sum_j \beta_j = 1, \sum_j \beta_{jk} = 0\ \forall k$, $\sum_j \beta_{jy} = 0$ and $\sum_j \beta_{jt} = 0$. $A(tt)$ represents the production technology. In this approach $A(tt)$ can be defined as two forms. If we encounter two regular periods of time (similar to the MGI), the GTTI is defined as $A(tt) = \sum_{h=1} \lambda_h (L_h t)$. If not (Similar to the GMGI), $A(tt)$ can for example be defined as, $A(t) = \lambda_2 L_{6\text{-}10} t + \lambda_3 L_{11\text{-}12} t + \cdots + \lambda_t L_{t-h-T} t$. Where, L_ts are Dummy Variables for Periods of time. This means that we choose a dummy variable for years 6-10 and another dummy variable for years 11-12. Therefore, we can compare technical change, return to scale and TFP growth of years 6-10 (5 years) with years 11-12 (2 years). This approach is also defined by two separate technological trends in each of the periods. Hence issues involving the degree of freedom and the existence of a constant trend are resolved.

Similar to the GI, MGI and GMGI, technical change in the GTTI model (TC/GTTI) is defined as

$$\begin{aligned}\text{TC/GTTI}_{it} &= -\left[A(tt) - A(tt-\text{h})\right] \\ &\left[\beta_a + 0.5\beta_{aa}\left[A(tt) - A(tt-\text{h}\right] + \sum_j \beta_{jt}\,\text{Ln}\, P_{jit} + \beta_{yt}\,\text{Ln}\, Y_{it}\right]\end{aligned} \tag{14}$$

Finally returns to scale is obtained from

$$\text{RTS/GTTI}_{it} = 1/(\partial \text{Ln}\, C_{it}/\partial \text{Ln}\, Y_{it}) = 1/(\beta_y + \beta_{yy}\,\text{Ln}\, Y_{it} + \sum_j \beta_{jy}\,\text{Ln}\, P_{jit} + \beta_{yt} A(tt)) \tag{15}$$

and TFP growth from

$$\dot{\text{TFP}} = Y - \sum_j S_j \dot{x}_j = \text{TC/GI} + \dot{Y}(1-(1/\text{RTS/GTTI})) \tag{16}$$

RESULTS AND RECOMMENDATIONS

In this paper, in order to compare the above mentioned methods, we use panel data from27 provinces of Iran's wheat production sector for the years of 2000 to 2007. Although the MGI, GMGI and GTTI methods are suitable for both time series data and panel data with small cross data, we used panel data in order to compare results with the GI and TT methods as well as with the Divisia Index Method.

Data was collected for the price and quantity of wheat, organic and chemical fertilizers, seeds, pesticides, machinery services, irrigation, labor and land. For estimation purposes, we aggregated the price of organic and chemical fertilizers, seeds, pesticides and irrigation in to a single intermediate input price using the Tornqvist-Tiel price index. Therefore the Translog cost function includes only four inputs; the intermediate price input, machinery services (as capital input), labor and land. TheTranslog cost Functions are estimated using the four different methodsie, the Time Trend, the General Index, the Modified General Index and the General

Time Trend Index. Regressions are estimated by nonlinear iterative seemingly unrelated method using *Shazam.11* Software. As mentioned in the Materials and Methods section, in estimating the wheat cost function, we used the TT, GI, MGI and GTTI. In order to compare these methods, we first estimated the wheat cost function using the TT and GI. Then technical change, return to scale and TFP growth for the years of 2000-2007 were calculated. Because we wanted to compare the period of 2006-2007with 2004-2005, an average of technical change, return to scale and TFP growth was calculated for each period. To estimate the wheat cost function using the MGI, we considered a dummy variable for every two years. This allowed us to compare any two-year time period. Next, technical change, return to scale and TFP growth for the period of 2006-2007and 2004-2005werecomputed. Because the time series of our data was limited, we choose every two years as a single time period.

We then estimated the wheat cost function using the GTTI. Similar to the MGI, we choose every two years as a period for comparison. Finally, TFP growth was calculated using the Divisia Index. The TFP growth calculated by the TT, GI, MGI and GTTI was compared to the Divisia Index. Technical change, return to scale and TFP growth for the periods of 2006-2007and 2004-2005calculated using the TT, GI, MGI, GTTI and the Divisia index are presented in Table 1.

Table 1: TFP growth Decomposition by TT, GI, MGI and GTTI

	Years	TT	GI	MGI	GTTI	Divisia*
TC	2004-2005	0.24780	0.10576	0.13305	0.15778	
	2006-2007	0.27527	0.00590	0.01855	0.07939	
RTS	2004-2005	1.23403	1.20419	1.03223	1.39654	
	2006-2007	1.23373	1.19149	1.03198	1.31714	
TFP growth	2004-2005	0.269	0.125	0.137	0.190	0.195
	2006-2007	0.300	0.027	0.023	0.110	0.107

**2000=100*

According to **Table 1**, Comparison of the TFP growth of the TT, GI, MGI and GTTI with the Divisia method shows that the GTTI is very similar to the Divisia index. Also, the MGI and the GI are relatively similar to the Divisia index however results from the TT method are not comparable to those of the Divisia index. These results also show that the GTTI is more suitable than other indices. Because of the similarity of the GI and MGI and based on the fact that the MGI can be used for both panel and time series data, it can be proposed that the MGI is better than GI (GI can only be used in panel data).The similarity of the GTTI and the Divisia index shows that the GTTI is the best index for Calculating TFP growth because on the one hand its results are close enough to the results from the Divisia index and on the other hand it allows for the use of time series data. In addition, we can compare different time periods as well as accommodate inconsistencies in technological trends over time.

Conclusion

Finally, when we have time series data or panel data with limited cross section data we recommend the MGI method for estimating technical change, return to scale, and TFP growth. When we need to compare irregular periods of time (for evaluation plan or policies), results show that the GMGI is the best index for estimating of technical change, return to scale, and TFP growth. When we have time series data or panel data with limited cross section data, and there is

an inconsistent trend in every time period, we can use the GTTI method for estimating technical change, return to scale, and TFP growth. Thus, utilizing these factors in economic agencies is necessary to increase the production based on modern technology, that is to say, economic development expansion requires continuous improvement in these factors.
The following chart shows the factors mentioned and their effects on the production process (Chart 1).

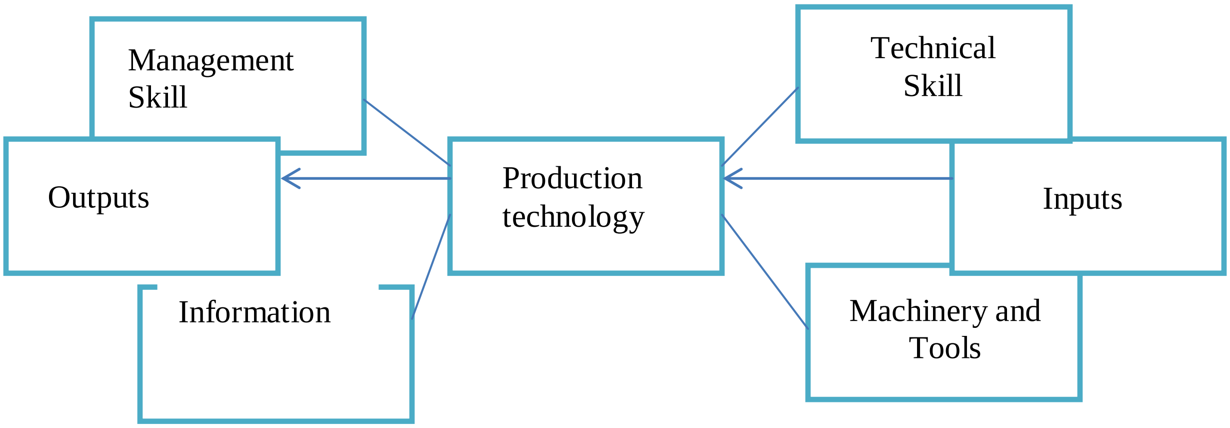

Chart 1.The factors influencing modern technology and their effects.

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