EFFICIENCY, TECHNICAL CHANGE AND PRODUCTIVITY GROWTH
IN INDONESIAN REGIONS

by
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Abstract
This paper aims to examine productivity growth across different Indonesian regions by extending the conventional Malmquist productivity index (MPI) into the meta and sequential production frontier concepts. These approaches use data envelopment analysis (DEA) technique to estimate productivity growth and its components. The metafrontier index can be decomposed into efficiency, best practice and technology gap changes, while the sequential index can be broken down into efficiency and technical changes. The empirical estimation is based on Indonesian regional data of twenty six provinces between 1985 and 2010. In order to estimate the metafrontier, the provinces are grouped into three different clusters. The results estimated through these multiple approaches are then compared. Moreover, a simple framework is proposed to describe the dynamic of Indonesian regional productivity growth and examine how the DEA-MPI concept can be related to innovation-based economic growth theory.

Key Words: Data envelopment analysis, Malmquist productivity index, Productivity growth, Technical change, Efficiency change, Indonesian regions
JEL Codes: C33, O47, O53

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SUMMARY

Thesis title: Efficiency, Technical change and Productivity Growth in Indonesian Regions
Supervisor: Professor Yanrui Wu

Indonesia, the fourth largest nation in terms of population and the largest economy in South-East Asia, has been categorized as a member of the emerging economies, emerging and growth leading economies (EAGLES), and growth markets\(^2\). The country is now implementing its new national development initiatives, economic reforms and decentralization policy. It has for the first time changed its highly centralized national government system by focusing on regional development policies and hence regional economic reforms. This new development strategy therefore faces two challenges. First, the central government must decide how to give more power to the regions which tend to govern their own budgets under the traditionally autonomous system. Second, Indonesia must improve the efficiency and productivity of its regions.

To achieve the goal of regional development in Indonesia, regional competitiveness has to be boosted through productivity growth and improvement in its components. Sigit (2004) argued that it is important to promote productivity as the main factor in economic development policy and decision making process in Indonesia. There is however a very long shadow between this goal and policy implementation. First, since the first five year national development plan (Pelita I, 1969-1974), productivity growth has never been explicitly mentioned as the national goal. Second, there is no capital stock data published at the regional level as the input data for productivity growth analysis. Third, Indonesia has no specific organization which promotes productivity as a countries culture as a productivity commission in Australia, CPC (China productivity center), national productivity council in India or Malaysian association of productivity.

This thesis thus performs a comprehensive study to deal with Indonesian regional productivity growth problems in eight integrated chapters. The first part examines the interrelation between productivity growth and recent development in Indonesia. The second part reviews the literature on productivity growth. This review focuses on the index methods, especially Malmquist productivity index, which is used in this study. The third segment estimates capital stock of Indonesian regions to establish a new database for regional productivity growth analysis. The fourth chapter measures productivity growth and its decomposition by employing conventional DEA-Malmquist productivity index which is extended to the next chapter by incorporating global benchmark to the technique. Finally, Indonesia’s and China’s regional productivity growth performance is compared. Both countries have been categorized as efficiency driven countries by the World Economic Forum however they perform very differently. This difference may be due to regional productivity growth variations. In addition, the determinants of Indonesian productivity growth will be considered in final section. These factors include information and communication technology (ICT), absorptive capacity, knowledge transfer and incentives. The last chapter concludes.

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\(^2\) The categories has been tagged by IMF, Banco Bilbao Vizcaya Argentaria, and Jim O’Neill of Goldman Sachs (creator of BRIC), respectively
I. Introduction

The 2012 World Bank and International Finance Cooperation (IFC) report on “Doing Business in Indonesia 2012” chooses the phrase “ambitious and fast rising” to describe the modern Indonesian economy. Evidence of this is seen through Indonesia being the third fastest growing economy among the G20 in 2009, with a predicted to growth rate of 6.4% for 2012 (World Bank and IFC, 2012).

Meanwhile, dramatic changes have taken place in Indonesia since 1998. The most fundamental and probably perilous decision path was the implementation of the decentralization policy and political reform during a period of crisis recovery. These two big tasks are characterized as “big bang” policies and have been called ‘the fastest and most comprehensive decentralization initiative ever attempt by any country’ (Alm, et al. 2001; USAID, 2002; and Guess, 2005).

These changes have been supported by the long term master plan; the plan to accelerate and expand the Indonesian economy from 2011 through 2025 (MP3EI). This master plan adopts a cluster system to improve the efficiency of the regional economy by helping them specialize according to their comparative advantages. The most interesting feature of this master plan is the explicit explanation given to the role of productivity growth. It concludes that productivity growth is the most important factor that should be considered and thus improved upon to allow for national development.

However, the emergence of the Nusantara has resulted in problems that need to be resolved. Hill (1995) remarked that despite the rapid industrialization that was accompanied by structural change, Indonesian technology development is among the lowest in East Asia. He also reminded us that technological development and technology policy must be the main focus of Indonesian economic development in the future.

It has been suggested that Indonesia’s economic growth can be attributed to the size and performance of its natural resource sector, despite the low levels of innovation present in its economy (Boediono, vice president, Kompas 9 Mei 2012). He mentioned that only 6 patents were registered in Indonesia in 2009, a low figure in comparison to other countries such as Japan and the US. The registration of trademarks was also lagging behind a series of

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3 This policy is based on the Law No. 22/1999 which gives constitutional foundations toward regional autonomy. Indonesia has also been implementing direct general election to choose their president –vice president, people representative and regional leader (Gubernur at province level and Bupati at regency level)

4 MP3EI is the master plan in which the Indonesian economy is divided into six integrated economic corridors to boost the exploration and development of natural resources and infrastructure in each cluster, by individually considering their economic potential (Coordinating Ministry of Economic Affair, 2011)

5 Nusantara is another name of the Republic of Indonesia
other countries in 2009; Indonesia had only 15 trademarks compared to the People’s Republic of China which had 84,000, Thailand which had 386, Malaysia which had 513 and the Philippines, which had 54.

In line with this, The World Economic Forum’s report on global competitiveness for 2011-2012 classified Indonesia as an economy that has been driven primarily by efficiency (in the same group with Malaysia, Thailand and China). This means that Indonesia’s economy is not driven by innovation as a source of sustainable long run growth, and hence the welfare of the country is not driven by this either. This makes it different from its neighboring countries such as Singapore, Australia, South Korea and Japan, which are driven by innovation.

This type of observation induces some research questions regarding Indonesian economic growth, primarily questions involving the issue of efficiency and innovation (components of productivity growth). These questions may be more relevant at the regional level in the context of the implementation of the decentralization policy. The first question is in regards to the regional structure of productivity growth in Indonesia. Secondly, whether the productivity growth decomposition at the national level has follows the same patterns in every region, and what the dominant factor behind this growth is. Thirdly, how the heterogeneity of Indonesian regions can affect productivity performance, and whether or not these differences manifest themselves in the results found through productivity growth estimation. The last question looks at whether productivity growth can explain Indonesian economic development paths, as well as looking at the implications of this for the past, present and future of Indonesian regional development.

Many studies have been completed to explore Indonesian productivity growth performance, however little consideration has been given to its decomposition, particularly at the regional level. The first estimation of regional total factor productivity (TFP) was done by Wibisono (2005), which looked at trends of inequality among the Indonesian regions. Isaksson (2006) as well as Krisnasamy and Ahmed (2008) examined the decomposition of Indonesian TFP growth at the national level as part of an international study. The longest time period of Indonesian productivity growth was estimated by Van Der Eng (2008), by using a growth accounting approach. Other papers that have addressed this topic include Abimanyu (1995), Osada (1994), Timmer (1999), Sigit (2001, 2004), and War (2009).

Nonetheless, the productivity growth of Indonesian regions has not been clearly explored in terms of its specific existence. This means that part of the productivity growth capturing by capital stock and education-adjustment of employment in Indonesia has not been fully expounded according to its components (Van Der Eng, 2009). As a consequence he
explained that the TFP resulting from growth accounting only accounted for productivity growth itself, without decomposing any of the factors reflected within it. This implies that the most important and urgent part of the productivity growth analysis is its decomposition.

To fill this gap, this paper explores Indonesian regional productivity growth performance by taking into account three stages of estimations. The first stage is done by employing a conventional DEA-Malmquist productivity index (DEA-MPI). The next step is the application of the sequential frontier, done by assuming that past technology will still feasible in the future. The last step is the metafrontier estimation which is done by considering that different regions have different technology frontiers.

The use of these methods enables the decomposition of TFP growth into efficiency, technical (best practice) and technology gap changes. Furthermore, some alternative schemes are evaluated to analyze a more complete portrayal of these components in the Indonesian development paths. They include looking at spatial context (TFP growth by island), TFP growth in five year development planning, pre and post crisis segmentation, the frontier shift and the technology gap ratio in economic development zones.

This study thus may be valuable in three different ways. First, it is the first study of aggregate TFP growth at the regional level in Indonesia, which uses DEA-MPI and hence analyzes the result in several different scenarios. Secondly, the examination uses different versions of the Malmquist productivity index, comparing the results and testing the effect of the different schemes of depreciation rate when applied in capital stock estimation. Thirdly, this study uses a simple framework to show how the DEA-MPI can be related to modern growth theory.

The structure of the paper is as follows. In the second section, the derivation of conventional DEA-MPI as well as sequential and metafrontier will be explained. The third and fourth parts are the results and the productivity growth in the Indonesian economic development setting, respectively. In the next sections, productivity growth is compared, starting with testing the impact of six scenarios of a depreciation rate applied in capital stock estimation to the productivity growth. Moreover in this section a simple framework is proposed to describe productivity dynamics and how the DEA-MPI can be related to the innovation based growth theory. The last section concludes the paper.
II. DEA Malmquist Productivity Index

*Conventional DEA-MPI*

DEA is a nonparametric approach that can be used to compare the performance of a decision making unit (DMU) with multiple inputs and outputs. DEA was first introduced by Charnes et al. (1978) as a form of mathematical programming used to estimate the efficiency of DMU according to Farrell (1957). Rather than assuming a particular production function, the DEA approach estimates a frontier as a benchmark to evaluate other units in the sample. As well as this valuable innovation method, DEA is a technique which relies on input-output data only and thus is without the requirement of price information.

Caves et al. (1982) combined the concepts of distance function in DEA in conjunction with the Malmquist consumer quantity index to evaluate the productivity performance of a unit of observations. This idea became prominent under the seminal work of Fare et al. (1994), who decomposed DEA-MPI into efficiency and technical change components. The Fare’s index is the geometric mean of two contemporaneous Malmquist indices as in Chaves et al. (1982). The complete derivation can be explained in the subsequent paragraph.

Let's denote output and input vector as \(y^t \in \mathbb{R}^{M_t^+}\) and \(x^t \in \mathbb{R}^{N_t^+}\). For \(t = 1, \ldots, T\), there are sets of production technology which can be presented as

\[ P^t = \{(x^t, y^t): x^t \text{ can produce } y^t\} \]  

(1)

Since \(x\) (input) can produce \(y\) (output) then the output distance function \(D_o\) at time \(t\) is defined as follows:

\[ D_o(x^t, y^t) = \inf \left\{ \theta: (x^t, y^t / \theta) \in P^t \right\} \]  

(2)

Following Fare et al. (1994), under a constant return to scale assumption, the Malmquist index can be written as the geometric mean of the distance function in the two time periods \(t\) and \(t+1\).

\[ M_o(x^{t+1}, y^{t+1}, x^t, y^t) = \left[ \frac{D_o(x^{t+1}, y^{t+1})}{D_o(x^t, y^t)} \frac{D_o(x^{t+1}, y^{t+1})}{D_o(x^t, y^t)} \right]^{1/2} \]  

(3)

This TFP growth index can be decomposed as

\[ M_o(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o(x^t, y^t)} \left[ \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \frac{D_o(x^t, y^t)}{D_o(x^t, y^t)} \right]^{1/2} \]  

(4)

Finally the equation (4) can be simplified as

\[ TFPCH = \text{Efficiency Change (EFFCH)} \times \text{Technical Change (TECCH)} \]
Sequential Frontier

Tulken and Eeckaut (1995) proposed the sequential frontier which was used to generate the frontier from period 1 up to time t. Suharyanto and Thirtle (2001) explained the curse of dimensionality in the DEA-MPI when the observation exceeds the variable in the sample. They solved this problem by incorporating the sequential frontier in the productivity growth estimation. Sestalova (2003) also utilized a sequential approach to productivity growth estimation in manufacturing industries of OECD countries by using 2 inputs and 1 output. All of these studies indicate that the time dimension in the panel data comes into the sequential set. Consequently, the technical change in the sequential approach is pure technical progress.

Let’s the output set at time t for the sequential frontier be derived as follows

\[ P_t(x) = \left\{ y : y \leq \beta Y^{(1,t)}, x \geq \beta X^{(1,t)}, \beta \geq 0, \beta \in \mathbb{R}^G \right\}, \]

where \( Y = (Y^1, ..., Y^{t-1}, Y^t) \) and \( X = (X^1, ..., X^{t-1}, X^t) \). This is the same notion as in the previous reference production set that was constructed at each point in time, but in Equation (6) the data from time t1 until t are considered. Therefore, Equation (6) can be written as

\[ P_t(x) = \left\{ y : y \leq \beta (Y^1, ..., Y^{t-1}, Y^t), x \geq \beta (X^1, ..., X^{t-1}, X^t), \beta \geq 0, \beta \in \mathbb{R}^G \right\}. \]

To differentiate conventional Malmquist indices from sequential ones, let’s denote SM as the sequential Malmquist indices

\[ SM_o (x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_o (x^{t+1}, y^{t+1})}{D_o (x^t, y^t)} \left[ \frac{D_o (x^{t+1}, y^{t+1})}{D_o (x^{t+1}, y^{t+1})} \cdot \frac{D_o (x^t, y^t)}{D_o (x^t, y^t)} \right]^{1/2} \]

Metafrontier

Recall the third research question in the introduction section; whether the different frontiers affect the estimation of productivity growth of the Indonesian regions. This revival of frontier differences amongst the group of observations has been addressed by a number of studies. Hill (1995) argued that although firms exist in the same industry, they are not guaranteed to have the same production function. Different firms and hence regions have been bounded by different choices of production. As a result, they combine their input-output in different ways (O’Donnell et al., 2008). This argument was explained by Hayami and Ruttan (1970) as meta production and is then applied by Battese, et al. (2004) in the stochastic frontier and Malmquist productivity index. Oh and Lee (2010) combined the approach by adding an intertemporal concept to the derivation of the model, on the basis of the global Malmquist of Pastor and Lovell (2005).

Following Oh and Lee (2010), the first step of the metafrontier framework is to estimate the intertemporal index by constructing a single production set from the whole time period of
the production plan of the group. Both of these are enveloped by the global frontier. Suppose that the contemporaneous reference technology set of group $C_j$ is $P_{Cj}^t$; then the intertemporal and global reference set will be

$$P^I = P_{C1}^t \cup P_{C2}^t \cup \ldots \cup P_{Cj}^t \quad \text{and} \quad P^G = P_{R1}^t \cup P_{R2}^t \cup \ldots \cup P_{Rj}^t$$

From this formulation, the intertemporal Malmquist indices can be formed as

$$M^I_o(x^{r+1}, y^{r+1}, x', y') = \frac{D^I_o(x^{r+1}, y^{r+1})}{D^I_o(x', y')} \quad (8)$$

which can be decomposed as

$$= \frac{D^I_o(x^{r+1}, y^{r+1})}{D^I_o(x', y')} \times \left[ \begin{array}{cc} D^I_o(x^{r+1}, y^{r+1}) & D^I_o(x', y') \\ D^I_o(x^{r+1}, y^{r+1}) & D^I_o(x', y') \end{array} \right]$$

$$= \frac{D^I_o(x^{r+1}, y^{r+1})}{D^I_o(x', y')} \times \left[ \begin{array}{c} D^I_o(x^{r+1}, y^{r+1})/D^I_o(x^{r+1}, y^{r+1}) \\ D^I_o(x', y')/D^I_o(x', y') \end{array} \right]$$

$$= \frac{TE^{r+1} x BPG^{I,r+1}}{TE^I x BPG^{I,r}}$$

$$= EFFCH x BPC x TGC \quad (9)$$

The global Malmquist indices can be written and decomposed as follows

$$M^G_o(x^{r+1}, y^{r+1}, x', y') = \frac{D^G_o(x^{r+1}, y^{r+1})}{D^I_o(x', y')} \quad (10)$$

$$= \frac{D^G_o(x^{r+1}, y^{r+1})}{D^I_o(x', y')} \times \left[ \begin{array}{cc} D^G_o(x^{r+1}, y^{r+1}) & D^G_o(x^{r+1}, y^{r+1}) \\ D^G_o(x^{r+1}, y^{r+1}) & D^G_o(x^{r+1}, y^{r+1}) \end{array} \right]$$

$$= \frac{D^G_o(x^{r+1}, y^{r+1})}{D^I_o(x', y')} \times \left[ \begin{array}{c} D^G_o(x^{r+1}, y^{r+1})/D^G_o(x^{r+1}, y^{r+1}) \\ D^I_o(x', y')/D^I_o(x', y') \end{array} \right]$$

$$= \frac{TE^{r+1} x BPG^{I,r+1}}{TE^I x BPG^{I,r}} \times \left[ \begin{array}{cc} D^G_o(x^{r+1}, y^{r+1}) & D^G_o(x^{r+1}, y^{r+1}) \\ D^G_o(x^{r+1}, y^{r+1}) & D^G_o(x^{r+1}, y^{r+1}) \end{array} \right]$$

$$= \frac{TE^{r+1} x BPG^{I,r+1}}{TE^I x BPG^{I,r}} \times \left[ \begin{array}{c} D^G_o(x^{r+1}, y^{r+1})/D^G_o(x^{r+1}, y^{r+1}) \\ D^I_o(x', y')/D^I_o(x', y') \end{array} \right]$$

$$= EFFCH x BPC x TGC \quad (11)$$

The first component of equation (11) is efficiency change, which is in the same function as Fare et al. (1994). This EFFCH represents a catch up to the frontier and can be technically described as a movement along the frontier line within the cluster. The second element is the best practice change, which is similar to technical change. The last component
is the technology gap change that can be interpreted as the ratio of the technology gap ratio across two time periods.

**Data and Grouping**

The data used to estimate DEA-MPI in this study are two inputs and one output that cover 26 provinces between 1985 and 2010. The first data used is the gross regional product (GRP) as an output factor. Employment data and capital stock by province are utilized as input factors. The capital stock data is based on the new database estimated by the perpetual inventory method using a common depreciation rate 0.05. The implementation of the method at the regional level can be expressed as:

\[ K_i^t = (1 - \delta)K_{i,t-1} + I_i^t \]  

(12)

where \( K_i^t \) is the capital stock of region \( i \) in year \( t \), \( I_i^t \) is the investment in region \( i \) in time \( t \) and \( \delta \) is the rate of depreciation. The issue of different regional rates of depreciation is addressed by Wu (2008), who points out the technical drawbacks of estimating the series if the depreciation rates are assumed by ad hoc values.

For metafrontier estimation, the data is divided into three different clusters. The grouping technique in this study is based on geography proximity. The same technique is used in O’Donell et al. (2008) but differs from Iyer et al. (2006), who used the income level. Three sea lines of Indonesian economic zones, namely the sea lane of communication (SLoC) and alur laut kepulauan Indonesia (ALKI) are considered for the geography proximity. The first is the Malacca and Sunda straits which form the boundary of Sumatera Island. The second one is the Lombok and Makasar Strait which is the borderline of the Kalimantan and Java-Bali Island. The last strait is Ombai Wetar, which is the dividing line between the west and east Indonesian Island, including Sulawesi, Maluku, Nusa Tenggara and Papua. Figure 2.1 shows the division of SLoC and ALKI.

However, the clustering treats Bali as within the third block rather than the second block since in the six corridors of MP3EI, Bali is in the same group with Nusa Tenggara, to support the tourism development zone. Clearly, the three clusters can be seen as Sumatera as...
the first, Java-Kalimantan as the second and Bali, Nusa Tenggara, Sulawesi, Maluku and Papua (BNSMP) as the third.

Figure 2.1 SLoC and ALKI of Indonesian regions

Source: Coordinating Ministry of Economic Affairs

III. Efficiency Change, Technical Change and Productivity Growth

Conventional DEA-MPI

The estimation results of DEA-MPI are presented in Table 3.1 which shows that, on average, the TFP of Indonesian regions increased by 1.07% annually. In the early years for the period of study, the productivity growth rate decreased to 1.70% and then increased steadily until 1996. There were significant improvements in the period 1987-1996 (2.70% on average), while there was a harsh decrease in productivity between 1997 and 1999 (3.61% on average), particularly in 1998 (9.57%). Subsequently, the productivity growth changed around 0.17-2.05% until 2009, and then decreased to 0.13% in 2010.

Table 3.1 Annual average of conventional DEA-MPI

<table>
<thead>
<tr>
<th>Year</th>
<th>EFFCH</th>
<th>TECCH</th>
<th>TFPCH</th>
<th>Year</th>
<th>EFFCH</th>
<th>TECCH</th>
<th>TFPCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>1986</td>
<td>1.0457</td>
<td>0.9400</td>
<td>0.9830</td>
<td>1999</td>
<td>0.9912</td>
<td>1.0009</td>
<td>0.9921</td>
</tr>
<tr>
<td>1987</td>
<td>1.0242</td>
<td>0.9853</td>
<td>1.0091</td>
<td>2000</td>
<td>1.0995</td>
<td>0.9236</td>
<td>1.0156</td>
</tr>
<tr>
<td>1988</td>
<td>1.0239</td>
<td>1.0138</td>
<td>1.0381</td>
<td>2001</td>
<td>1.1140</td>
<td>0.9145</td>
<td>1.0188</td>
</tr>
<tr>
<td>1989</td>
<td>1.0198</td>
<td>1.0103</td>
<td>1.0303</td>
<td>2002</td>
<td>0.8879</td>
<td>1.1494</td>
<td>1.0205</td>
</tr>
<tr>
<td>1990</td>
<td>1.0462</td>
<td>0.9728</td>
<td>1.0177</td>
<td>2003</td>
<td>1.0339</td>
<td>0.9801</td>
<td>1.0133</td>
</tr>
<tr>
<td>1991</td>
<td>0.9894</td>
<td>1.0473</td>
<td>1.0362</td>
<td>2004</td>
<td>1.0603</td>
<td>0.9615</td>
<td>1.0195</td>
</tr>
<tr>
<td>1992</td>
<td>1.0472</td>
<td>0.9757</td>
<td>1.0218</td>
<td>2005</td>
<td>1.1902</td>
<td>0.8572</td>
<td>1.0202</td>
</tr>
<tr>
<td>1993</td>
<td>1.0082</td>
<td>1.0150</td>
<td>1.0234</td>
<td>2006</td>
<td>1.0648</td>
<td>0.9447</td>
<td>1.0060</td>
</tr>
<tr>
<td>1994</td>
<td>1.0345</td>
<td>0.9818</td>
<td>1.0157</td>
<td>2007</td>
<td>1.0871</td>
<td>0.9289</td>
<td>1.0097</td>
</tr>
<tr>
<td>1995</td>
<td>1.0962</td>
<td>0.9724</td>
<td>1.0659</td>
<td>2008</td>
<td>1.0919</td>
<td>0.9175</td>
<td>1.0017</td>
</tr>
<tr>
<td>1996</td>
<td>1.0143</td>
<td>0.9984</td>
<td>1.0127</td>
<td>2009</td>
<td>1.0610</td>
<td>0.9474</td>
<td>1.0053</td>
</tr>
<tr>
<td>1997</td>
<td>1.0455</td>
<td>0.9548</td>
<td>0.9982</td>
<td>2010</td>
<td>1.0146</td>
<td>0.9844</td>
<td>0.9987</td>
</tr>
<tr>
<td>1998</td>
<td>1.0054</td>
<td>0.8994</td>
<td>0.9043</td>
<td>GMean</td>
<td>1.0425</td>
<td>0.9696</td>
<td>1.0107</td>
</tr>
</tbody>
</table>
Figure 3.1 shows that the trends for Indonesian productivity growth exhibit a V-shaped or potentially a U formation. Blanchard (1996) stated that countries with a U-shaped evolution of output (and hence productivity growth) are characterized as countries in transition. Correspondingly, Mubyarto (2000) categorized the period 2001-2008 as the transition period needed to find a new format for the Indonesian economy. The difference between the two stories is that the transition period in Indonesia was not induced by the change from a less to more efficient economy as argued by Blanchard, but rather by an economic crisis.

**Figure 3.1** TFPCH estimated by conventional DEA-MPI

Another interesting feature seen in Figure 3.1 is that the TFP progress after crisis was lower than before the downturn. Blanchard (1996) explained that if the initial unemployment in a country with transition is relatively high, it will lead to a slow restructuring process. Related to this, there was an irregularity in Indonesia during the economic crisis as the unemployment rate was only 5.5%. It was far below the projection of the Task Force ILO and the National Planning Bureau (Table 3.2).

**Table 3.2** Labour indicators during the economic crisis

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Projection: National Planning Bureau</td>
<td>13.6</td>
</tr>
<tr>
<td>Task Force ILO</td>
<td>10.0</td>
</tr>
<tr>
<td>*Survey: BPS (CBS Indonesia)</td>
<td>5.5</td>
</tr>
<tr>
<td>**Decreased employment in formal sector</td>
<td>31.7 m (1997) to 30.3 m (1998)</td>
</tr>
<tr>
<td>**Decrease Number of employed in formal sector</td>
<td>53.7 m (1997) to 57.3 m (1998)</td>
</tr>
</tbody>
</table>

*Source: *Priyono (2002) and **Feridhanusetyawan (2002)*

Arsana (2008) examined this irregularity by applying matching function frameworks to the formal and informal job flows in the crisis period. He concludes that the flow from a formal to informal sector ends up with the superficial conclusion that the impact of the crisis was trivial to the Indonesian labor market. The low rate of unemployment was caused by the

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9 *The italic words is based on the finding in this paper*
movement from high to low (formal to informal) productivity growth sectors. This may be one of the reasons why productivity growth decreased sharply between 1997 and 1999. The data supports this tendency. Formal employment decreased during the crisis period from 31.7 million in 1997 to 30.3 million in 1998 while the number of informal workers increased from 53.7 million in 1997 to 57.3 million in 1998 (Table 3.2).

At the regional level, the highest productivity growth was shown by DKI Jakarta, followed by Central Sulawesi and Jambi (Table 3.3). Based on the island’s geometric mean, Java-Bali exhibited the highest progress, followed by Manupa and Sulawesi. In the spatial estimation we will see how these trends match up with modern growth theory. The geometric mean and the rank of the island’s TFPCH can be seen in Table 3.3.

Table 3.3 Conventional DEA-MPI by regions

<table>
<thead>
<tr>
<th>Regions</th>
<th>EFFCH</th>
<th>TECCH</th>
<th>TFPCH</th>
<th>Regions</th>
<th>EFFCH</th>
<th>TECCH</th>
<th>TFPCH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>NAD</td>
<td>0.9977</td>
<td>0.9483</td>
<td>0.9461</td>
<td>West Kalimantan</td>
<td>1.0388</td>
<td>0.9760</td>
<td>1.0139</td>
</tr>
<tr>
<td>North Sumatera</td>
<td>1.0473</td>
<td>0.9742</td>
<td>1.0202</td>
<td>Central Kalimantan</td>
<td>1.0197</td>
<td>0.9797</td>
<td>0.9990</td>
</tr>
<tr>
<td>West Sumatera</td>
<td>1.0498</td>
<td>0.9746</td>
<td>1.0231</td>
<td>South Kalimantan</td>
<td>1.0551</td>
<td>0.9665</td>
<td>1.0198</td>
</tr>
<tr>
<td>Riau</td>
<td>1.0021</td>
<td>0.9881</td>
<td>0.9902</td>
<td>East Kalimantan</td>
<td>1.0000</td>
<td>0.9878</td>
<td>0.9878</td>
</tr>
<tr>
<td>Jambi</td>
<td>1.0568</td>
<td>0.9687</td>
<td>1.0237</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Sumatera</td>
<td>1.0309</td>
<td>0.9750</td>
<td>1.0052</td>
<td>North Sulawesi</td>
<td>1.0534</td>
<td>0.9670</td>
<td>1.0186</td>
</tr>
<tr>
<td>Bengkulu</td>
<td>1.0542</td>
<td>0.9360</td>
<td>0.9867</td>
<td>Central Sulawesi</td>
<td>1.0566</td>
<td>0.9697</td>
<td>1.0246</td>
</tr>
<tr>
<td>Lampung</td>
<td>1.0591</td>
<td>0.9590</td>
<td>1.0158</td>
<td>South Sulawesi</td>
<td>1.0512</td>
<td>0.9654</td>
<td>1.0148</td>
</tr>
<tr>
<td><strong>Sumatera (rank 5)</strong></td>
<td><strong>1.0370</strong></td>
<td><strong>0.9654</strong></td>
<td><strong>1.0011</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DKI Jakarta</td>
<td>1.0261</td>
<td>0.9991</td>
<td>1.0252</td>
<td>Sulawesi (rank 3)</td>
<td>1.0523</td>
<td>0.9664</td>
<td>1.0170</td>
</tr>
<tr>
<td>West Java</td>
<td>1.0398</td>
<td>0.9746</td>
<td>1.0133</td>
<td>West Nusa Tenggara</td>
<td>1.0546</td>
<td>0.9664</td>
<td>1.0191</td>
</tr>
<tr>
<td>Central Java</td>
<td>1.0542</td>
<td>0.9663</td>
<td>1.0187</td>
<td>East Nusa Tenggara</td>
<td>1.0729</td>
<td>0.9443</td>
<td>1.0131</td>
</tr>
<tr>
<td>DI Yogyakarta</td>
<td>1.0477</td>
<td>0.9730</td>
<td>1.0194</td>
<td>Maluku</td>
<td>1.0547</td>
<td>0.9704</td>
<td>1.0235</td>
</tr>
<tr>
<td>East Java</td>
<td>1.0434</td>
<td>0.9753</td>
<td>1.0177</td>
<td>Papua</td>
<td>1.0395</td>
<td>0.9748</td>
<td>1.0133</td>
</tr>
<tr>
<td>Bali</td>
<td>1.0550</td>
<td>0.9669</td>
<td>1.0201</td>
<td>Manupa (rank 2)</td>
<td>1.0554</td>
<td>0.9639</td>
<td>1.0172</td>
</tr>
<tr>
<td><strong>Java-Bali (rank 1)</strong></td>
<td><strong>1.0443</strong></td>
<td><strong>0.9758</strong></td>
<td><strong>1.0191</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GMeanTotal</strong></td>
<td><strong>1.0425</strong></td>
<td><strong>0.9696</strong></td>
<td><strong>1.0107</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Tables 3.1 and 3.3 also reveal that the dominant factor contributing to TFP growth for the Indonesian regions is efficiency change. This is empirical proof behind the statement of the vice president, Boediono, (Kompas 9 Mei 2012) that the Indonesian economy has not been driven by innovation, which is equivalent to productivity growth being dominated by technical change. This also supports the premise that Indonesia is categorized as a country in the stage of being driven by efficiency. Empirically, this argument is very strong for the period of the study, since on average, almost all the regions experienced EFFCH improvement except NAD.
The technical change seen in the regions deteriorated both on aggregate as well as regionally. On average, the deterioration of TECCH was 3% during the periods of this study. This negative trend has a similar pattern to the UK technical change for the period 1965-1990 (Moudos et al. 1998) and the four Asian Tigers for the period 1960-1990 (Kruger, 2003). However, yearly estimation shows that there was technical progress in 1988, 1989, 1991, 1993, 1999, with the best performance found in 2002 (14.9%).

**Figure 3.2** TECCH estimated by conventional DEA-MPI

These results imply that there was technical progress discontinuity in the Indonesian regions. It can also be argued that the time lag of technology diffusion in Indonesian regions occurs across a longer period than for these countries. Another reason is the presence of technological breaks that are embodied in the country’s business cycle. Figure 3.2 clearly displays the discontinuity of technical progress with only some line charts above the border line (equal to one) not being followed by the line above the border subsequently.

**Spatial Pattern**

The estimation results by island show that, on average, all the islands experienced productivity improvement except Kalimantan (Table 3.4). Three islands exhibited positive efficiency changes; Sumatera, Kalimantan and Manupa. Sumatera had the highest EFFCH (3.5%) followed by Manupa and Kalimantan. Java-Bali and Sulawesi experienced EFFCH deterioration. However, both of these islands presented technical progress, as did Manupa. The results of these islands differ from the aggregate level which on average shows a negative TECCH.

**Table 3.4** Conventional DEA-MPI by island

<table>
<thead>
<tr>
<th>Island</th>
<th>EFFCH</th>
<th>TECCH</th>
<th>TFPCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Sumatera</td>
<td>1.0350</td>
<td>0.9699</td>
<td>1.0038</td>
</tr>
<tr>
<td>Java-Bali</td>
<td>0.9997</td>
<td>1.0057</td>
<td>1.0054</td>
</tr>
<tr>
<td>Kalimantan</td>
<td>1.0036</td>
<td>0.9833</td>
<td>0.9868</td>
</tr>
<tr>
<td>Sulawesi</td>
<td>0.9993</td>
<td>1.0173</td>
<td>1.0166</td>
</tr>
<tr>
<td>Manupa</td>
<td>1.0040</td>
<td>1.0019</td>
<td>1.0059</td>
</tr>
</tbody>
</table>

---

10 Four Asian Tiger including Hong Kong, South Korea, Singapore and Taiwan
This spatial estimation shows two interesting points. The first is that the good performance of Java-Bali, Sulawesi and Manupa (TFPCH more than 0.5 %) match with the role of technical change as explained in modern growth theory. The positive TFPCH of the islands was accompanied by TECCH progress (Figure 3.3). Therefore, the high level of TFPCH could be caused by this factor. In addition, this effect was considerably stronger in Sulawesi and Java-Bali since their TFPCH was dominated by technical change. These results also reveal the second irregularity seen in the Indonesian regions. We can see from the conventional approaches that, on average, the Indonesian region’s TECCH was negative. In contrast, in a spatial context, the average of fourteen provinces (53.85 %) shows a positive TECCH\textsuperscript{11}.

Secondly, the overall estimation shows that TFPCH was dominated by the EFFCH. On the contrary, in the spatial estimation, Java-Bali and Sulawesi exhibit TFPCH dominated by technical change. These findings imply that the aggregate picture of productivity performance does not show Java-Bali as having the profile of the most developed region. These findings simply mean that if Indonesia as a whole wants to strengthen its performance, then it has to maintain and make sure that the outer-east islands (Kalimantan, Sulawesi, Maluku, Papua and Nusa Tenggara, Figure 3.3) are not “falling behind”. In other words, focus on these islands the most required policy implementation for the future.

**Figure 3.3 TECCH by island**

![Sequential Frontier](image)

*Sequential Frontier*

From the previous estimation, it is clear that one of the problems for the Indonesian economy is the negative technical change. Although some islands were characterized by a positive TECCH and were dominated by this factor, this cannot affect the performance on a national level. We can argue that the negative results are the logical consequence of the approach used

\textsuperscript{11} This is based on Table 3.4 in which Java-Bali includes 6 provinces, Sulawesi includes 4 provinces and Manupa includes 4 provinces (14 provinces in total)
in the estimation. The method is a one moment in time estimation, which is very useful to assess the change between two time periods. As shown in the methodology section, some scholars argue that technical change is a reflection of the long run evolution of technology. Consequently, past technology is still feasible in the future. This argument was developed in the DEA-MPI framework in the form of a sequential frontier.

The most compelling result of this sequential approach is the positive value of TECCH. There is no room for negative TECCH in this estimation. The result of TECCH can be seen in Table 3.5. Sulawesi experienced the highest TECCH growth (0.36 %) followed by Java-Bali (0.28 %) and Manupa (0.26 %). Sumatera posed the lowest TECCH among the other regions.

**Table 3.5 TECCH estimated by sequential DEA-MPI**

<table>
<thead>
<tr>
<th>Island</th>
<th>TECCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sumatera</td>
<td>1.0019</td>
</tr>
<tr>
<td>Java-Bali</td>
<td>1.0028</td>
</tr>
<tr>
<td>Kalimantan</td>
<td>1.0025</td>
</tr>
<tr>
<td>Sulawesi</td>
<td>1.0036</td>
</tr>
<tr>
<td>Manupa</td>
<td>1.0026</td>
</tr>
<tr>
<td>Total</td>
<td>1.0026</td>
</tr>
</tbody>
</table>

Comparing the total average with the regional averages, there are three groups that exhibit TECCH at an above aggregate level; Sulawesi, Java and Manupa. These findings again support the previous argument that the east development zone, including Sulawesi, Kalimantan and Manupa, play an important role in determining the economic growth performance of Indonesia. We can see that their TECCH (2.9 %), on average, was higher compare to the West (Sumatera and Java-Bali, 2.8 %).

A positive TECCH in the sequential frontier approach may avoid the presence of technical change discontinuity in Indonesia. However, although this is commonly not the concern for this estimation technique, the yearly average gives a sign to the phenomena. Figure 3.4 show this discontinuity. Most of the line chart is flat, implying TECCH is equal to one. This means that in most of the years there was neither deterioration nor improvement in technical change. The high levels of improvement in technical change occurred in 1989 (3.02 %) and in 1991 (2.64 %). This achievement was not continued in subsequent years. Although the TECCH was positive in 1993, 2004 and 2007, the improvement was under 0.5 %. In other words, technology was stagnant in this period of study.

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12 Manupa’s TECCH in five digit was 1.00264 while total was 1.00257
Metafrontier

As explained in the method and data section, to estimate metafrontier, the Indonesian data has been segmented into three clusters. Table 3.6 shows the results of metafrontier DEA-MPI in the clusters. TFP growth has the highest rate in cluster 3, followed in turn by cluster 2 and cluster 1. The good performance of the third cluster, which mainly consists of the east economic development zone, implies that the east could become the engine for economic growth. Appropriate policy needs to be managed to improve all the regions that can affect the aggregate economy in the future. One of the policies that has been related to this argument is the President decree 13/2000 (amended by President decree no 44/2002)\(^{13}\). This regulation tried to promote a more equitable development of the Indonesian regions. Whether or not this policy affects regional performance could be an interesting exercise for future research.

**Table 3.6 Metafrontier DEA-MPI by cluster**

<table>
<thead>
<tr>
<th>Cluster</th>
<th>EFFCH</th>
<th>BPC</th>
<th>TFPCH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Cluster 1</td>
<td>1.0350</td>
<td>0.9759</td>
<td>1.0063</td>
</tr>
<tr>
<td>Cluster 2</td>
<td>1.0100</td>
<td>0.9848</td>
<td>1.0130</td>
</tr>
<tr>
<td>Cluster 3</td>
<td>1.0042</td>
<td>1.0035</td>
<td>1.0193</td>
</tr>
<tr>
<td>Total</td>
<td>1.0156</td>
<td>0.9885</td>
<td>1.0131</td>
</tr>
</tbody>
</table>

Another interesting result is that only this group of regions experienced a positive sign of BPC. Other clusters show negative BPC but positive EFFCH, meaning that the innovation was not the dominant source of the TFPCH. The questionable result from this estimation is the negative sign of the BPC for the second cluster, which includes Java, one of the most developed regions in Indonesia. The similar trend can also be seen in the first cluster (Sumatera); although this region exhibited the highest EFFCH among the other clusters, the negative sign of the BPC must be a concern for policy implementation regarding economic growth in the region.

\(^{13}\) *President decree 13/2000: the establishment of East Indonesian Development Board.*
Yearly results for the metafrontier can be seen in the line chart found in Figure 3.5. From this figure we can see that the EFFCH line is mostly higher than TECCH line. Although both of them are associated with efficiency and technical change within the group, their movements could represent the overall TFPCH trends. In other words, this implies that the TFPCH of the Indonesian regions was dominated by the efficiency change for the period of study, when the index used was generated from the metafrontier approach.

**Figure 3.5** EFFCH, TECCH and TFPCH estimated by metafrontier

### IV. Productivity Growth and Indonesian Economic Development

The historical illustration of the relationship between economic development and productivity growth has been explained by Wu (2008). He clearly elucidated this stage of economic development by using an example from China’s growth experience. Wu stated that there are four stylist facts of growth, such as managing this growth through learning, opening, restructuring and efficiency improvement. These stages perhaps give a new insight and can be developed as a model of economic development. Whether these terminations can be observed in the Indonesian regions depends on how the structural change takes place in the economic development paths which can be evaluated through the evolvement of regional productivity growth.

In this section, there are three scenarios that will be considered to assess the evolution of Indonesian regional productivity growth and economic development. The first is to follow the breakthrough of TFP growth over time as a guide for further analysis. The second path is the assessment of the frontier shift, which can explain the direction of strategic policy taken by the particular regions. The last method is to analyze the technological gap change (TGC) and technological gap ratio (TGR) as a result of the metafrontier estimation.

**TFPCH over Time**

Two kinds of time references will be described in this section. The first is the Pelita periods and the second is the pre and post economic crisis periods. Table 4.1 shows the Indonesian
productivity growth decomposition based on Pelita. This table reveals that the highest TFPCH was achieved in the period from 1989 to 1994 (2.29 %). This was in the boom era for the Indonesian economy. The second highest period of TFPCH was from 1999 to 2004 (1.75 %), reflecting the recovery period after the economic crisis. The worst TFPCH achievement was for the period 1994-1999, which is easy to understand since this period includes the economic crisis.

However, the questionable part is for the period 2004 to 2010 which exhibits significant lower progress than for the previous period. It was one decade after the economic crisis. The period has been remarked as the most constitutional government era, as a result of a direct presidential election. The beginning of the period was four years after the implementation of the decentralization policy, and by 2010 it was almost ten years later. The question that is related to the low TFPCH for this period is whether the decentralization policy dampened the productivity growth of Indonesian regions, or whether other mechanisms and channels might give reasonable arguments for this.

The plausible answer may be seen in Okamoto and Sjoholm (2001) argument that in the presence of an economic crisis in Indonesia, complex problems make it difficult to concentrate on the technological development. As a result, the technical change deteriorates more than for the previous developmental stage. This might be true if we think about the segmentation discussed by Mubyarto (2000) in which Indonesia struggles to find a new economic format after the "big bang" decentralization policy. As a consequence, its productivity performance has not fully recovered and is more closely related to that of an economy in transition.

**Table 4.1** Conventional DEA-MPI by Pelita

<table>
<thead>
<tr>
<th>Period</th>
<th>EFFCH</th>
<th>TECCH</th>
<th>TFPCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985-1989</td>
<td>1.0284</td>
<td>0.9869</td>
<td>1.0149</td>
</tr>
<tr>
<td>1989-1994</td>
<td>1.0249</td>
<td>0.9981</td>
<td>1.0229</td>
</tr>
<tr>
<td>1994-1999</td>
<td>1.0299</td>
<td>0.9645</td>
<td>0.9933</td>
</tr>
<tr>
<td>1999-2004</td>
<td>1.0358</td>
<td>0.9824</td>
<td>1.0175</td>
</tr>
<tr>
<td>2004-2010</td>
<td>1.0837</td>
<td>0.9292</td>
<td>1.0069</td>
</tr>
</tbody>
</table>

Regionally, the evolution of TFPCH can be seen in Figure 4.1. This figure show that the general pattern of TFPCH among the regions follows the aggregate pattern, which started to increase in the first period, reached its peak in the second period and then decreased sharply from 1994-1999 before recovering in 1999-2004 and then mainly decreasing in 2004-2010.
All regions exhibited a relatively high TFPCH growth in the second period except Sumatera. Two regions experienced positive growth for the period 1994-1999, with a growth rate above the aggregate rate (Sulawesi and Manupa). Despite positive growth in the crisis period, Manupa also revealed the highest growth for the last period compared to its previous achievement, the other regions and the aggregate average. These regions also, in general, showed relatively higher rates compared to the aggregate average (the red dash line above the orange line). In contrast, Sumatera (blue line) was always below the orange line. Sulawesi (green) and Java-Bali (purple) were always above the orange line except for the periods 1999-2004 and 1994-1999 respectively.

The next segmentation for the Indonesian economy is between the pre and post crisis period. Table 4.2 shows the TFPCH before and after crisis for uncommon trends. The other regions (not in the table) indicate the regions experienced the common trend of aggregate movement in which the TFPCH was relatively high in the period before the economic crisis and decreases (but still remaining positive) after the economic crisis.

**Table 4.2 TFPCH before and after crisis estimated by conventional DEA-MPI**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td></td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Riau</td>
<td>+</td>
<td>-</td>
<td>North Sulawesi</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Jambi</td>
<td>+</td>
<td>&gt; +</td>
<td>Maluku</td>
<td>+</td>
<td>&gt; +</td>
</tr>
<tr>
<td>South Sumatera</td>
<td>+</td>
<td>&gt; +</td>
<td>Papua</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>West Java</td>
<td>+</td>
<td>&gt; +</td>
<td>NAD</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>East Nusa Tenggara</td>
<td>+</td>
<td>&gt; +</td>
<td>Bengkulu</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Central Kalimantan</td>
<td>+</td>
<td>-</td>
<td>East Kalimantan</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

The table reveals that some regions performed better after crisis (TFPCH increased and positive) including Jambi, South Sumatera, West Java, East Nusa Tenggara, Maluku and Bengkulu. Four regions (Riau, Central Kalimantan, North Sulawesi and Papua) exhibited decreasing movement (from positive before crisis to negative TFPCH after crisis). Both NAD and Kalimantan show stagnant movement (negative to negative TFPCH).
**Frontier shift**

Basically, frontier shifts are the scrutiny observation for the model suggested by Fare et al. (1994) as shown in the RHS of Equation 4. This technical change consists of two elements; the first and the second components are \( D_o^o(x^{i+1}, y^{i+1})/D_o^{r+1}(x^{i+1}, y^{r+1}) \) and \( D_o^f(x^f, y^f)/D_o^{r+1}(x^f, y^r) \) respectively. Based on the work of Chen and Ali (2004), there are nine possible movements for the technical change components which can be summarized in three general patterns as follows:

<table>
<thead>
<tr>
<th>Case</th>
<th>I</th>
<th>II</th>
<th>TECCH</th>
<th>Case</th>
<th>I</th>
<th>II</th>
<th>TECCH</th>
<th>Case</th>
<th>I</th>
<th>II</th>
<th>TECCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&gt;1</td>
<td>&gt;1</td>
<td>&gt;1</td>
<td>2</td>
<td>&lt;1</td>
<td>&gt;1</td>
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<td>3</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>2</td>
<td>&gt;1</td>
<td>&lt;1</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Note: I and II are the first and second components of TECCH while the question mark (?) mean uncertain.

Table 4.3 presents the results of a frontier shift for the three selected years. Comparing the first three yearly columns and the second ones, we observe three movements of the regions\(^\text{14}\). Pure negative movement is if both of the columns are less than one. Pure positive movement occurs if both of them are greater than one. The cross shift occurs if there is mix between less and greater than one. The first category can be seen in 2005, where all of the regions in the first and second column show a value less than one. The cross movement can be seen in 1996. The positive shift, unfortunately, cannot be observed in the case of the Indonesian regions. However, the shift in the year 2002 can be seen as a positive shift excluding Riau and East Kalimantan. Another way to view this year as a positive shift is by assuming that the TFPCH above 0.98 is a positive facet, since both Riau and East Kalimantan depict a technical change component above this value.

The main factor that induces the cross shifts of technical change is the decision making unit’s strategies used to upgrade their performance. Moving from negative to positive changes means that the regions have succeeded in implementing their strategy decisions in the related period. In 1996, almost all regions performed consistently (both the TECCH components had the same sign) and only North Sulawesi changed (negative to positive). In 2002, only East Kalimantan changed its performance (negative to positive). The change for North Sulawesi and East Kalimantan has a different result. The former experienced a TECCH regression in 1996 but the latter’s technical change was progressive.

\(^{14}\) The shifts depend on the value of the first and the second component of technical change. If \( D_o^o(x^{r+1}, y^{r+1})/D_o^{r+1}(x^{r+1}, y^{r+1}) \) less than one and \( D_o^f(x^f, y^f)/D_o^{r+1}(x^f, y^r) \) more than one then the unit categorized as move from positive to negative facet and other way around.
Table 4.3 Frontier shift in selected years

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<td>South Kalimantan</td>
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<tr>
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<td>Central Sulawesi</td>
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<td>&lt;1</td>
<td>South Sulawesi</td>
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<td>&lt;1</td>
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<td>Maluku</td>
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<tr>
<td>East Java</td>
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<td>&gt;1</td>
<td>&lt;1</td>
<td>Papua</td>
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</table>

The frontier shift can be one of the indicators which can be used to see what is going on in particular regions. The negative shift in the year 2005 in all of the regions is a key concern for the policy maker. The positive movement in the year 2002 also can be compared to that in other years. As an early signal, this frontier shift can be combined with other indicators to get a more complete picture of the regional development. In the next discussion we will see one of the possible indicators that may be used to see the deeper story of the frontier shift.

**Technology Gap**

The technology gap is the opportunity deviation to acquire science and technology between both the people as a whole and people as an individual entity (UNCSTD, 2006). Therefore, the persistence of this will affect the diversity of sectoral development either at a regional or national level. The technology gap also can be viewed by looking at the advantage of backwardness, in which the catch up process allows the lagging regions or countries to grow faster than the leading ones (Greunz, 2001). Based on these propositions, we now seek to explore whether or not the technology gap and its consequences persist in Indonesian regions.

According to the conventional approach, the technology gap can be perceived as the difference in productivity performance in terms of technical change. Two points should be mentioned. The first is the TFPCH being dominated by technical change in Java-Bali implies that there is a technology gap between developed and underdeveloped regions in Indonesia. Conformably, the developed region (Java-Bali) has an advantage in technological development that supports their productivity growth. Secondly, the dominant factor of technical change in Sulawesi, as one of the outer-underdeveloped regions, can be recognized
as an example of the advantage of backwardness. Table 3.4 confirms that TECCH and hence TFPCH of Sulawesi was the highest among other islands. This signals that the lagging regions grows faster in term of technology development compared to leading regions.

Unlike the conventional approach, the metafrontier method directly measures the technology gap by capturing the change in the gap between two time periods (TGC) and the distance to the global frontier (TGR). Table 4.4 shows that Java-Kalimantan was the cluster with the highest technology gap change, and that Sumatera had the lowest amount. To be consistent with the west-east development zone, we can separate Java-Kalimantan into Java and Kalimantan respectively. Consequently, we can see that average TGC of the east, including Kalimantan and BNSMP, is higher than for the west. This implies that the technology leader most likely will move to the east. The dominant factor of this movement could be caused by the change of leadership in terms of technology development of Sumatera relative to the outer-east islands.

**Table 4.4 TGC and TGR by cluster**

<table>
<thead>
<tr>
<th>Cluster</th>
<th>TGC</th>
<th>TGR</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Sumatera</td>
<td>0.9963</td>
<td>0.8563</td>
</tr>
<tr>
<td>Java-Kalimantan</td>
<td>1.0185</td>
<td><em>1.0181</em></td>
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<td><em>Java</em></td>
<td><em>1.0181</em></td>
<td><em>0.6635</em></td>
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<td><em>Kalimantan</em></td>
<td><em>1.0189</em></td>
<td></td>
</tr>
<tr>
<td>BNSMP</td>
<td>1.0116</td>
<td>0.3085</td>
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However, this change should be interpreted in conjunction with the technology gap ratio formulated in equation 11, in which the technology gap change is derived from technology gap ratio in time t+1 over time t. It means that TGR determines how close the country is to the global technology frontier. As we can see the TGR of Sumatera was the highest among the other islands, meaning that, on average, these regions are closer to the frontier technology compared to the others. However these regions lost the power to speed up their development, which is represented by the negative value for the technology gap change. This is a nice example of the process of catch up to the technology frontier as explained by Howit and Mayer-Foulkes (2004), in which the closer the countries or regions are to the frontier, the lower the growth rate of the productivity.

This is not a good sign for the Indonesian economy as a whole. This tendency reveals that Indonesian regions probably get trapped with old technology trajectories and cannot adapt well to the advanced development technologies. The catch up process then becomes the process of moving closer to the low level of the national frontier, which in turn lags behind
the world technology frontier. This last proposition is the essence of the DEA-MPI in which the distance to the frontier is the core of the method. However, different approaches give different angles of analysis and it is worthwhile to compare DEA-MPI in other growth frameworks. The most favorable choice for comparison is the innovation based growth theory developed by Howitt and Mayer-Foulkes (2005)\textsuperscript{15}.

The summary of the yearly movement of the technological gap can be seen in Table 4.5, which presents the regions in the frontier with a technology gap ratio equal to 1. Three regions in the Sumatera islands were in this frontier in some of the periods. Only East Kalimantan was observed in the frontier in Kalimantan Island. The most interesting finding is that DKI Jakarta was in the frontier almost for the entire period of study. On average, only this province was in the frontier with an aggregate average TGR equal to one. This is a very convincing result, as the capital city, Jakarta, dominated the technological development. It could also still be the result of the long term centralization policy utilized in Indonesia. Jakarta still has a dominant role in technological advancement after the decentralization policy. However, this role seems likely to spread to the other provinces, as seen by East Kalimantan also being in the frontier for the period 2001-2010, one decade after the implementation of the decentralization policy.

Table 4.5 Regions in the frontier based on TGR

<table>
<thead>
<tr>
<th>Province</th>
<th>Year in the frontier (technical gap ratio =1)</th>
</tr>
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<tbody>
<tr>
<td>Bengkulu</td>
<td>1986, 1988</td>
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</tbody>
</table>

V. Comparing Productivity Growth

Sensitivity Analysis

Before comparing the different approaches of DEA-MPI, it is worthwhile to consider the effect of a different depreciation rate being applied in capital stock estimation to the DEA-MPI. This sensitivity analysis also fills the gap in the literature regarding whether or not the depreciation rate has a significant effect on the productivity growth estimation, particularly in the DEA-MPI framework. Empirically, this test can give a clue to the debate of what depreciation rate would have to be chosen for the Indonesian regions if the objective of the

\textsuperscript{15} This will be done in section V
study is to estimate and analyze the productivity growth performance by utilizing DEA-MPI. Figure 5.1 (a-c) shows the productivity growth as estimated by conventional, sequential and metafrontier DEA-MPI in different scenarios.

As we can see, the six schemes have a similar pattern. All of the line charts stick together and become almost identical. These results mean that the different depreciation rates applied to the capital stock estimation in the perpetual inventory method (PIM) have a little impact to the DEA-MPI and hence productivity growth performance. If the difference in the depreciation rate is associated with the different methods of capital stock estimation, then the findings of Figure 5.1 support the conclusion of Domazlicky and Weber (1992) that productivity growth is less sensitive to capital measurement. The exceptional effect of depreciation on capital stock estimation for Indonesia (Bu, 2006) which in turn affects the productivity growth estimation is confirmed by the insensitive effect of the depreciation rate on productivity growth in this study.

**Comparing the approaches**

After gaining an insight into productivity growth under different depreciation rates, the subsequent logical step for this analysis is to compare the productivity growth performance using different theoretical frameworks. The three approaches (conventional, sequential and metafrontier) of DEA-MPI are formed using different techniques and it is thus reasonable that
the results achieved from the three sets of analysis are different. We will then deal with the structure of these differences and whether or not these differences are significant enough to require us to comment.

Figure 5.2 shows how the average of productivity growth is very similar when using any of the three methods. We can see that the regions that have a negative TFPCH in one of the methods also tend to have a negative TFPCH in the other methods, except in the case of Bengkulu, which exhibits a negative TFP in the conventional method but a positive result using the other two methods.

The sequential method (red line) depicts a higher TFPCH (compare to blue line) in NAD, Riau, Bengkulu, Lampung, Central Java, Bali, West and East Nusa Tenggara, South and East Kalimantan, North Sulawesi and South and South East Sulawesi. The similar trends can also be observed by comparing metafrontier (black dash line) with conventional approach (blue line). However, on average, it can be seen that the sequential approach shows the highest growth (1.33 % compare to the metafrontier (1.31 %) and conventional (1.07 %) approaches. The same tendency was shown by the TECCH but not for the EFFCH, in which the conventional approach exhibits the highest growth (4.25 %) compared to sequential (1.07 %) and metafrontier (1.56 %) approaches.

Looking at the differences by grouping the regions together can give us a deeper insight into the contrast among the methods. Figure 5.3 shows that the gap between TFPCH estimated using different methods is relatively high for Sumatera and considerably smaller in Java-Kalimantan and BNSMP. More variations can be seen in TECCH and EFFCH. The former was mostly higher for the sequential approach, followed by metafrontier and conventional respectively. An interesting result derived from the figures is that the TECCH for the sequential and metafrontier approach for BNSMP was relatively similar.
Table 5.1 illustrates the correlation of the three methods. The findings are different in value with the correlation of the contemporaneous and sequential in Sestalova (2003), which are 0.98 for productivity growth and 0.68 and 0.56 for efficiency change and technical change respectively. However, these values indicate the same conclusion as Sestalova (2003); that both of the methods show a similar productivity growth but differences in efficiency and technical changes.

The conventional, sequential and metafrontier approaches may coincide each other. Pastor and Lovel (2005) argued that a sufficient condition for equality of the global Malmquist and contemporaneous is the Hicks output neutrality of technical change. Sestalova (2003) argues that both sequential and contemporaneous Malmquist index will coincide if the two frontiers move together, if the shifts of the contemporaneous frontier are Hicks neutral.

Oh and Heshmati (2010) also found that for productivity growth both sequential and conventional metafrontiers exhibit similar trends. The different between the findings of this study and their findings is that the coefficient correlation between efficiency change of conventional and sequential index was found to be negative in their study. In this study, we found that the coefficient correlation is positive, which is similar to the finding of Sestalova (2003). However both Sestalova and Oh and Hesmati (2010) explained that the efficiency change of a conventional index and a sequential index is different in the theoretical framework. It can be seen in Figure 5.3, the line chart of efficiency change of the sequential index being far below the line chart of the conventional approach.
Table 5.1 Correlation of productivity growth components

<table>
<thead>
<tr>
<th></th>
<th>CEFFCH</th>
<th>SEFFCH</th>
<th>MEFFCH</th>
<th>CTECHC</th>
<th>STECHC</th>
<th>MTECHC</th>
<th>CTFPCCH</th>
<th>STFPCH</th>
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<tr>
<td>CEFFCH</td>
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<tr>
<td>SEFFCH</td>
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<td>1</td>
<td>.323</td>
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<tr>
<td>MEFFCH</td>
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<tr>
<td>CTECHC</td>
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<td>.328</td>
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<tr>
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<td></td>
<td></td>
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<tr>
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<tr>
<td>CTFPCCH</td>
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<tr>
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</table>

Another possible explanation concerning the differences of these frontiers, especially the contemporaneous and sequential frontiers, is based on the explanation of the frontier shift in the previous section. The efficiency change and technical change in the sequential approach is different since in the sequential approach technical regress is not possible. As a result, the productivity decline is transferred through the efficiency change deterioration (Sestalova, 2003; Oh and Lee, 2010).

**DEA MPI and Innovation-based growth theory**

Both sensitivity analysis and methods comparison in this section juxtapose the empirical results of different scenarios of productivity performance. To get more insight of the comparison we can algebraically explain how the within and between productivity growth frameworks can be related. Of the great concern is the terms technology gap and technical change associated with innovation.

Firstly, we can compare that the technology gap change in Equation 11 is equal to metafrontier ratio in O’Donell et al. (2008) or technology gap in Iyer et al. (2006) and Iyer (2011). The formulation can be written as follows

\[
TGC_{t,r+1} = \frac{TEC - m_{t,r+1}}{TEC - g_{t,r+1}}
\]  

(13)

Rambaldi et al. (2007) named these terms as growth index of technology gap ratio. The consequence of this is that the TGC of Equation 11 will represent the change in the leadership of the technology. The closer the regions to the meta technology frontier the lower the TGC since the shift of the group technology is faster than the shift of metafrontier. The result confirms these trends in which Sumatera Island with high TGR experienced negative TGC since on average the regions in this island are close to the metafrontier technology.

\[\text{Complete derivation can be seen in Appendix I}\]
Secondly, the concept of innovation has been attributed to technical change as the shift of frontier from across period. Standard DEA MPI implicitly describes this in the second term of RHS of Equation 4. By comparing two frameworks (DEA MPI and innovation-based growth theory) this termination could be explicitly determined as follows:

\[
\frac{TEC - g.TC - g}{TEC - M.TC - M} = \left(1 - \frac{a_i}{1 + g_i}\right) \frac{\mu_{i}}{\mu_{i} - \mu_{i}}
\]  

(14)

This last expression show a very interesting result in which the technology change of regions depends much more on their individual competitiveness and current innovation rates of the regions. The technology gap change is negatively related to its normalized productivity and growth of frontier. The tailored models of this framework clearly explain that the term technology change in DEA-MPI is associated with competitiveness and innovation rate of unit of analysis. Further, the technical gap change and hence technology gap ratio depends much more on the growth of the frontier technology. Both of these terminations cannot be shown by using DEA-MPI formulation but could be illustrated via a graphical model. This framework also implies that to catch-up with world technology frontier, Indonesian regions would be governed in such a way that their competitiveness and regional innovation meets the requirement of world leader technology frontier. In doing so, the components of \( \mu \) have to be clearly examined as the key factors to encourage regional innovation system and it will be an interesting future research in the case of Indonesian regions.

VI. Conclusion

The study of productivity growth at the regional level in Indonesia sheds more light on regional development. It fills the gap in literature on regional productivity growth in the country by employing a DEA-MPI technique and decomposing productivity growth into its components. This topic becomes important in the growing discussion centered on the implementation of the decentralization policy.

The estimations indicate that most of the Indonesian regions improved their productivity growth for the period of study. This productivity growth was mainly attributed to an efficiency change. The decomposition also depicts the lag of technology implementation, which is observed as the technical progress discontinuity occurs. The disparity of productivity performance implies that some regions cannot manage input factors properly. Therefore, promoting balanced development is essential for productivity performance. This policy may also imply balanced growth between EFFCH and TECCH.

\( ^{17} \text{Complete derivation can be seen in Appendix II} \)
The spatial pattern of productivity growth was characterized by the combination of lagging and developed regions to the aggregate productivity growth. The dominant effect of the east development zone makes it clear that the success of some of the developed regions cannot support the overall economic development. Java-Bali, the most developed region, may not play a dominant role in the subsequent economic development in Indonesia. These spatial patterns also imply that it is time to go to the east, since the future of Indonesian economic development depends much more on boosting productivity growth in these development zones through the support of balanced improvements in efficiency and technical change.

The failure of Indonesian development to achieve development take off in the fourth Pelita can be explained by analyzing the productivity growth across time. National development, in particular economic development, is a continuous process. It is reasonable to conclude that balanced improvement of efficiency change and technical change is the key factor in promoting economic development in the long run. The failure to maintain the technical change improvement after 1994 made it difficult for Indonesia to achieve this take-off phase. This worsens when the economic slowdown plays a role in the transition period.

By using a simple framework we show that the competitiveness and rate of innovation play important roles in supporting Indonesian regional productivity growth. Therefore, flow of information, ideas, technological advancements and new inventions must be the main target to stimulate the knowledge transfer and technology diffusion at the regional level.

### Appendix I

Basically, the simple framework tends to examine the technology gap change and technology gap ratio in conjunction with Howitt and Mayer-Foulkes (2005). Recall the right hand side of Equation (11) as follows

$$TGC = \frac{TGR_{t+1}}{TGR_t}$$

We can see that technology gap change is the ratio of two TGR in two time periods. Next, we will see how this ratio equal to the ratio of technical efficiency with respect to global frontier (TEC-m) and technical efficiency with respect to group frontier (TEC-g). Following Rao et al. (2004), Rambaldi et al. (2007), O’Donell et al. (2008) and Krismayany and Ahmed (2009), let’s define

$$TGR_t = \frac{TE - m_t}{TE - g_t} \quad (A1)$$

As a consequence

$$TE - m_t = TE - g_t \cdot TGR_t \quad \text{and} \quad TE - m_{t+1} = TE - g_{t+1} \cdot TGR_{t+1} \quad (A2)$$

Let’s also define
\[ TE_{C} - m_{t,i+1} = \frac{TE - m_{i+1}}{TE - m_{i}} \quad \text{and} \quad TE_{C} - g_{t,i+1} = \frac{TE - g_{i+1}}{TE - g_{i}} \quad (A3) \]

Insert A2 into the first terms of A3, we will get

\[ TE_{C} - m_{t,i+1} = \frac{TE - g_{i+1, TGR_{i+1}}}{TE - g_{i, TGR_{i}}} \]

And it is clear that

\[ TGC_{t,i+1} = \frac{TE_{C} - m_{t,i+1}}{TE_{C} - g_{i+1}} \quad (A4) \]

**Appendix II**

The relative movements of group frontier and the metafrontier and the distance between them have been the concern of various studies. What mechanisms and factors interplay behind the movements could clearly be determined by equalizing the terms catch-up in DEA-MPI and productivity growth of Howitt and Mayer-Foulkes (2005). The terms catch-up explained in Rambaldi et al. (2007) and Krisnasamy and Ahmed (2009) can be written as

\[ \frac{MPI - g}{MPI - m} \quad (A5) \]

This equation compares the within group (region) and the metafrontier (national or aggregate) TFP growth. It is equivalent to compare country with world frontier in Howitt and Mayer-Foulkes (2005). In this paper we will relate these two frameworks and explain the relation between them. Let’s starts with the catch up terms.\(^{18}\)

\[ \frac{MPI - g}{MPI - m} = \frac{TEC - g}{TEC - m} \]

The first component of right hand side of A6 is the inverse of technology gap change (TGC) and the second one is the ratio between technical changes of group to the metafrontier. If the technical change is associated with innovation (as commonly remarks in DEA-MPI analysis), than the second part of this equation is the group over the aggregate innovation.

In the same spirit, Howitt and Mayer-Foulkes (2005) formulated the growth of country (G) and world (g) productivity between t and t+1 period as follows

\[ g_{t,i+1} = \frac{\bar{A}_{t,i+1} - \bar{A}_{t,i}}{\bar{A}_{t,i}} \quad \text{and} \quad G_{t,i+1} = \frac{A_{t,i+1} - A_{t,i}}{A_{t,i}} \]

Where \( \bar{A}_{t,i} \) and \( A_{t,i} \) are world and countries productivity respectively. This two productivity growth was examined in the Schumpeterian growth framework (Aghion-Howitt, 1992) which is called as innovation based growth theory. In this framework, both G and g were derived so that we have the following expressions:

\[ g_{t,i+1} = \frac{\mu a_{i}}{\mu_{t}} - 1 \quad \text{and} \quad G_{t,i+1} = \mu \left( 1 - \frac{a_{i}}{1 + g_{t,i+1}} \right) \quad (A7) \]

\(^{18}\) For simplicity both MPI-g and MPI-m are decomposed as in Fare et al. (1994)
Where $\mu$ is country’s competitiveness, $\mu_t$ is country’s innovation rate and $a_t$ is normalized productivity which is equal to $A_i / \bar{A}_i$. The catch-up formulation in A5 therefore can be derived as

$$\frac{MPI - g}{MPI - m} = \frac{G_{t+1}}{g_{t+1}}$$

By combining Equation A6 and A7 then we have:

$$\frac{TEC - g.TC - g}{TEC - m.TC - M} = \mu\left(1 - \frac{a_t}{1 + g_t}\right)$$

therefore

$$\frac{TEC - g.TC - g}{TEC - m.TC - M} = \left(1 - \frac{a_t}{1 + g_t}\right) \frac{\mu \mu_t - \mu_t}{\mu}$$

(A8)

References:


19 For complete derivation of this formulation, please refer to Howitt and Mayer-Foulkes (2005)


