

# Bank Efficiency and Productivity Change in Hong Kong and Macau

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## Abstract

Hong Kong and Macau are Special Administrative Regions in China and share many characteristics. As one of the four key industries in both regions, the banking sector has undergone profound changes over the course of the past 15 years due to the 1997 Asian Financial Crisis, the global economic downturn of 2001 to 2002, and the transition to Chinese management in the late 1990s. Using a data envelopment analysis approach, this paper comparatively analyzes the evolution of technical efficiency and productivity change in major commercial banks in Hong Kong and Macau over the period from 1995 to 2006. The results obtained therein suggest that banks in Hong Kong and Macau have enjoyed a relatively high level of efficiency and moderate productivity growth over this sampling period. Hong Kong banks outperformed Macau banks in terms of technical efficiency, whereas Macau banks outperformed Hong Kong banks in terms of productivity growth. Interestingly, there were considerable variations in technical efficiency and productivity change amongst various groups of differently sized banks. According to this study, the measures that have been adopted by regulators and bank management to tackle the challenges that have been caused by the financial crisis and economic downturn have been very effective. In addition, the performance of banks in both markets have benefitted from a closer relationship with Mainland China, especially for Macau banks. Finally, technical growth was the main reason for total factor productivity growth in both markets.

JEL classification: G21

Keywords: Hong Kong banking, Macau banking, Bank efficiency, Productivity change

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## 1. Introduction

Efficiency and productivity change have long been the focus of banking research. Findings in relation to these topics have important implications to policy makers who are concerned about bank safety and soundness, as well as for bank managers who seek to improve operating performance. Considerable research has been conducted for US and European commercial banks; however, there have been comparatively few studies that have investigated banks in Asia (Berger and Humphrey, 1997; Isik and Hassan, 2003). This paper contributes to the literature by comparatively analyzing the evolution of the technical efficiency and productivity change of commercial banks in two Asian economies, namely, Hong Kong and Macau, from 1995 to 2006.

Hong Kong and Macau are unique environments for the investigation of bank efficiency and productivity growth; moreover, they are two closely related economies that have many shared characteristics and experiences. First, Hong Kong and Macau have been Special Administrative Regions (SARs) of China since the late 1990s after having been colonized by the United Kingdom and Portugal, respectively, for over a century.<sup>3</sup> Therefore, the banking sector in both regions is heavily influenced by China's economic development as well as by various policies that have been adopted by China's central government after the transition to Chinese management of these regions. Second, the banking industry has been one of four key industries that have greatly contributed to the economic development of both regions over the sampling period. Third, both regions have adopted the linked exchange rate system. Under this system, the Macau pataca is pegged to the Hong Kong dollar, which in turn is linked to the US dollar. This implies that both regions are also heavily affected by the US economy. Finally, both regions have a long tradition of laissez-faire economies during

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<sup>3</sup> Hong Kong became a colony of the British Empire in 1942, while Macau was colonized by Portugal in 1557. In addition, under the policy of "one country, two systems", the Chinese central government is responsible for the SARs' defence and foreign affairs, whereas the SARs maintain their own legal system, police force, monetary system, customs policy, immigration policy, and delegates to international organizations and events.

their respective colonial periods and both are committed to maintaining this free market stance under Chinese administration. Overall, the banking industries in both markets have undergone substantial changes during the sampling period due to the 1997 Asian Financial Crisis, their transition to Chinese administration in late 1990s, and the global economic downturn of 2001 to 2002.<sup>4</sup>

Interestingly, there are also substantial differences between the banking sectors of these two regions. First, Hong Kong is an international financial center with around 150 licensed banks and a well-developed financial market. The Hong Kong Stock Exchange is the seventh largest in the world and had a market capitalization of USD2.35 trillion in 2009. In the same year, Hong Kong raised 22% of worldwide IPO capital, making it the largest center of initial public offerings in the world.<sup>5</sup> In contrast, Macau is an open but small economy with only 24 banks with full licenses and a comparatively less developed financial market. In fact, there is no stock market in Macau. Second, banks in Hong Kong are larger than banks in Macau in terms of asset size. The average asset size of the Hong Kong banks that were sampled in this study is HKD221.2 billion, whereas the average asset size of the Macau banks that were sampled in this study is HKD8.8 billion. Third, in comparison to Macau banks, Hong Kong banks have developed more complicated products to both satisfy the needs of their general customers and improve their risk management mechanisms. Macau banks typically offer traditional banking products to their customers (e.g. current and savings accounts, loans, and bank cards). A few of them provide very limited investment services, such as foreign exchange trading and share brokerage services. In contrast, Hong Kong banks frequently offer securities, unit trusts, bonds, and various forms of structured products to satisfy customer investment needs.<sup>6</sup>

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<sup>4</sup> The global economic downturn of 2001 to 2002 emerged from the US business sector. This economic downturn was further exacerbated by the financial repercussions of the 9/11 terrorist attack, which eventually resulted in a global economic recession.

<sup>5</sup> Source: World Federation of Exchanges (2009)

<sup>6</sup> Source: De Ficção Multimedia Projects (2007)

By employing a data envelopment analysis (DEA) approach, this paper estimates technical efficiency and the Malmquist total factor productivity (TFP) change index for banks in Hong Kong and Macau over the period of 1995 to 2006. Specifically, this paper examines both trends and fluctuations in the Malmquist TFP change index over the aforementioned sampling period. In addition, the components of the Malmquist TFP change index are also estimated, and the driving forces of Malmquist TFP changes are identified. Finally, technical efficiency is also examined.

The contributions of this study to the existing literature are as follows. First, this is the first study to provide explicit comparisons of bank efficiency and Malmquist TFP changes in China's two SARs. Second, this study identifies the driving forces of Malmquist TFP changes in the two economies. Third, this study considers more recent data in comparison to previous studies (e.g. Kwan, 2006; Drake et al. 2006; Hall et al. 2008). Importantly, one advantage of looking at the period of 1995 to 2006 is that it covers the 1997 Asian Financial Crisis, the transitions to Chinese administration in the late 1990s, and the global economic downturn of 2001 to 2002.

The rest of the paper is organized as follows. Chapter 2 briefly describes the banking sectors in Hong Kong and Macau. Chapter 3 illustrates the theoretical framework and reviews previous empirical studies. Chapter 4 explains the methodology and data. Chapter 5 discusses the obtained empirical results, and the last chapter concludes the study.

## **2. Overview of the Banking Sectors in Hong Kong and Macau**

Hong Kong is an international financial center. The financial services industry is one of four key industries that are driving the growth of Hong Kong's economy. Its percentage share to GDP was on average 12.73% for the period of 1996 to 2008. Meanwhile, the banking sector plays a dominant role in the financial services industry.

Its contribution to GDP was on average 8.62% during the same period.<sup>7</sup> Hong Kong's banking sector is comprised of three types of authorized institutions, including licensed banks, restricted license banks, and deposit-taking companies. All of these are authorized to take deposits from the general public, but only licensed banks can provide basic commercial banking services to their customers, such as operating checking and savings accounts, accepting deposits of any size and maturity, and paying or collecting checks that are drawn by or paid in by customers.<sup>8</sup> Given the various restrictions that are imposed on restricted license banks and deposit-taking companies, this study focuses on the evolution and performance of licensed banks. In March 2010, there were 147 licensed banks in Hong Kong. Among these, 23 licensed banks were locally incorporated, and the rest were branches of foreign banks. The total deposits and assets that were held by licensed banks in March 2010 were HKD6.45 trillion and HKD10.64 trillion, respectively.

The Hong Kong Monetary Authority (HKMA) is Hong Kong's banking regulator, which was established in April of 1993. The HKMA is responsible for the maintaining of monetary and banking stability. The HKMA adopted the linked exchange rate system in 1983. Under this system, the Hong Kong dollar is officially linked to the US dollar at the rate of 7.8 Hong Kong dollars to 1 US dollar.<sup>9</sup> In addition, the HKMA gradually deregulated the interest rate between 1994 and 2001 to stimulate competition in the banking sector. In the first phase of interest rate deregulation (1994 to 1999), the interest rates of various types of time deposits were liberalized, whereas in the second phase (2000 to 2001), the remaining interest rate caps were removed. With regard to the restrictions that have been imposed on foreign

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<sup>7</sup> Financial services, trading and logistics, tourism, and producer and professional services are the four key industries in the Hong Kong economy. Financial services cover a wide range of services, including banking, insurance, stock brokerage, asset management, and other financial services. (Source: Hong Kong Census and Statistics Department, 2010)

<sup>8</sup> Restricted licence banks are engaged in wholesale and capital market activities and may only take deposits in amounts of at least HK\$500,000 without restrictions on maturity. The deposit-taking companies are restricted to taking deposits of HK\$100,000 or above with an original term to maturity of at least three months. (Source: HKMA, 2010)

<sup>9</sup> The linked exchange rate system is maintained through a currency board system. This ensures that Hong Kong's entire monetary base is backed with US dollars at the linked exchange rate. The resources for this backing are kept in Hong Kong's Exchange Fund, which is one of the largest official reserves in the world. (Source: HKMA, 2010)

banks, the HKMA relaxed the so-called “one-building” restriction to a “three-building” restriction in 1999 and eventually abolished the restriction altogether in 2001.<sup>10</sup> Market entry criteria for foreign banks were also liberalized in 2002 (Hall et al. 2008). Finally, the HKMA has issued various regulations so as to ensure the safety and stability of the banking system. For example, locally incorporated banks in Hong Kong are required to adhere to the Basle minimum of an 8% capital adequacy requirement, whereas all authorized institutions are required to meet a minimum monthly average liquidity ratio of 25%. Furthermore, a deposit protection scheme with a coverage limit of HKD100,000 per depositor per bank was enacted in September 2006. All licensed banks in Hong Kong are members of this protection scheme.<sup>11</sup>

Similar to what has been observed for Hong Kong, the banking industry has been one of four key industries that have driven economic development in Macau, and, moreover, the banking industry has comprised, on average, 7.85% of Macau’s GDP for the period of 1996 to 2008. All of the banks in Macau are retail banks with full banking licenses, except for two off-shore banks. In March 2010, there were 24 banks with full licenses,<sup>12</sup> wherein 10 were locally incorporated and 14 were branches of foreign banks. The total bank deposits and assets were around MOP0.30 trillion (HKD0.29 trillion) and MOP0.44 trillion (HKD0.43 trillion) for these locally incorporated and foreign branch banks, respectively.<sup>13</sup>

The Autoridade Monetária de Macau (AMCM) was created in 1989 and is responsible for the formulation and implementation of monetary policy and the oversight of financial institutions in Macau. The AMCM has also adopted the linked exchange rate system. Under this system, the Macau pataca is pegged to the Hong Kong dollar at the

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<sup>10</sup> The “one-building” restriction means that foreign banks may only maintain offices in one building for the purpose of conducting banking business. The “three-building” restriction means that they can operate from three separate buildings instead of one. (Source: HKMA, 2010)

<sup>11</sup> For more details, please refer to the official website of the HKMA ([www.info.gov.hk/hkma/index.htm](http://www.info.gov.hk/hkma/index.htm)).

<sup>12</sup> The postal savings office is excluded.

<sup>13</sup> Source: HKMA, 2010

rate of MOP1.03 per Hong Kong dollar.<sup>14</sup> In addition, the Financial System Act was promulgated in 1993 with the introduction of banking reforms so as to ensure the soundness of the banking system in Macau. This act adopted the recommendations of the Basle Committee, and various rules were introduced afterward. For example, all Macau banks must meet the minimum capital adequacy ratio and liquidity ratio of 8% and 20%, respectively. Finally, the AMCM issued a series of guidelines and rules concerning internal bank control and risk management in the 2000s in order to help Macau banks enhance their financial performance in a safe and prudent manner and ensure that Macau banks are able to maintain stability and enhance their ability to combat risks.<sup>15</sup>

The banking sectors in both Hong Kong and Macau have been heavily influenced by a number of important events over the course of the last 15 years, primarily the 1997 Asian Financial Crisis, the transition to Chinese administration in the late 1990s, and the economic downturn of 2001 to 2002. First, banks in Hong Kong and Macau greatly suffered during the 1997 Asian Financial Crisis. Most of these banks experienced continuous deterioration in asset quality as well as a sharp decrease in profitability from 1997 to 1998. As can be observed in Table 1, the average return on assets (ROA) decreased from 1.39% and 1.05% in 1997 to 0.86% and 0.75% in 1998 for banks in Hong Kong and Macau, respectively. The average cost to income ratio rose from 39.5% to 42.10% for Hong Kong banks and from 51.86% to 66.29% for Macau banks. Meanwhile, the average ratio of bad debt charge to total assets increased from 0.19% to 0.60% for Hong Kong banks and from 0.19% to 0.49% for Macau banks. To address these problems, banks in Hong Kong and Macau have adopted some new strategies, such as building up liquidity and increasing their level of caution and selectiveness in their lending practices. Loan review and collection procedures have been improved to ensure that banks are able to identify problem

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<sup>14</sup> The Macau pataca has been officially linked to the Hong Kong dollar since 1977. In 1989, it was announced that pataca's link to the Hong Kong dollar was broken, and the unit was set free to float. However, the pataca's effective rate is still viewed as closely pegged to the Hong Kong dollar (Scott, 1997).

<sup>15</sup> For details, please refer to the official website of the AMCM ([www.amcm.gov.mo](http://www.amcm.gov.mo)).

loans at an early stage and take action to protect their financial positions. Banks have also become more proactive in their asset and liability management, especially in terms of funding strategy and how to price their deposits against the competition.<sup>16</sup>

*Table 1 inserted here*

Second, Hong Kong and Macau became SARs of China in 1997 and 1999, respectively. These transitions to Chinese administration have strengthened the economic relationship between Hong Kong, Macau, and Mainland China under the implementation of policies, such as the Closer Economic Partnership Arrangements (CEPAs) and the liberalization of tourism as per the Individual Traveler Scheme (ITS). The CEPAs are free trade agreements between Mainland China and the Hong Kong and Macau governments. They were introduced in January 2004 and give preferential access to the Mainland market for Hong Kong and Macau companies. The CEPAs for Hong Kong and Macau are similar; however, under the specific framework of the CEPAs, Macau banks at present cannot directly tap into the Mainland market by setting up subsidiaries due to size limitations. According to the CEPAs, Hong Kong and Macau banks are required to have more than USD6 billion in assets in order to set up branches in the Mainland. From a practical standpoint, some banks in Hong Kong are able to satisfy this asset requirement; however, no banks in Macau are able to satisfy this requirement because the assets that are held by the largest locally registered bank only amount to USD3 billion. Thus, the CEPAs have helped promote the expansion of Hong Kong-incorporated banks in Mainland China but not Macau-incorporated banks. For example, through the CEPAs, eight Hong Kong-incorporated banks have become eligible to establish branches in the Mainland. Among these, five banks opened six new Mainland branches as of the end of 2008. In addition, banks in both Hong Kong and Macau have been allowed to conduct Renminbi (RMB) business for individuals as of early 2004 under the CEPAs. The first

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<sup>16</sup> Sources: HKMA (2010) and AMCM (2010)

RMB-based bankcard was issued in both regions in 2004.<sup>17</sup> These bankcards are connected to China's UnionPay network, which was used by over 400,000 merchants and 50,000 ATMS in the Mainland in 2009.

The ITS, which took effect in July 2003, allows travelers from Mainland China to visit Hong Kong and Macau on an individual basis. Prior to this scheme, Mainland residents could usually only travel to Hong Kong and Macau on business visas or in group tours.<sup>18</sup> The outbreak of the Severe Acute Respiratory Syndrome from March to June 2003 resulted in a sharp decrease in the number of both Mainland and overseas visitors, which adversely impacted the tourism industry. To boost the economies of Hong Kong and Macau, the Mainland government launched the ITS. This scheme resulted in an immediate surge in the number of Mainland visitors. In the short period from July 28 to November 4, 2003, more than 600,000 individuals in the Mainland applied for visas, and 450,000 visas were issued. The number of visitors under this scheme reached two million in May 2004.

In general, there is a wide recognition that Mainland China offers substantial opportunities for banks in Hong Kong and Macau in terms of both new business development and the ability to expand their relationship with existing customers. Consequently, the average ROA of banks in Hong Kong and Macau increased from 1.18% and 0.63% in 2003, respectively, to 1.39% and 0.85% in 2004; these figures further increased to 1.40% and 1.57%, respectively, in 2005. Meanwhile, the average ratio of bad debt charge to total assets decreased from 0.29% and 0.58% in 2003 to 0.02% and 0.31% in 2004, and it further decreased to 0.01% and 0.18% in 2005 for Hong Kong and Macau, respectively. In addition, the substantial positive impact of the transition to Chinese administration in 1999 is particularly true for in Macau. In

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<sup>17</sup> Hong Kong and Macau have their own respective currencies. According to the "one country, two systems" principle and the basic laws of the two territories, national laws generally do not apply. Therefore, the Hong Kong dollar and the Macanese pataca remain the legal tenders in the two territories, and Renminbi, although sometimes accepted, is not legal tender.

<sup>18</sup> Under the initial stage of the scheme, citizens of Beijing, Shanghai, and eight cities in Guangdong province could apply for visas to visit Hong Kong and Macau individually. In July 2004, the scheme was extended to all 21 cities of Guangdong and 9 other cities in the Jiangsu, Zhejiang, and Fujian provinces.

this region, the average ROA increased from 0.06% in 1999 to 0.54% in 2000, whereas the average ratio of bad debt charge to total assets and the cost to income ratio decreased from 0.95% and 97.26% to 0.85% and 78.70%, respectively, over the same period. For banks in Hong Kong, such a pattern cannot be identified due to the mixed effects of the 1997 Asian Financial Crisis and the transition to Chinese administration.

Finally, both Hong Kong and Macau are open and free economies; hence, they were both heavily influenced by the global recession of 2001 to 2002. The ROA of banks in Hong Kong and Macau decreased by 0.11% and 0.13% between 2000 and 2001, respectively. Meanwhile, the contribution of banking activities to GDP decreased by 0.2% and 0.6% in Hong Kong and Macau, respectively.

### **3. Brief Literature Review**

In the banking literature, only a handful of academic studies have measured efficiency and productivity changes in Hong Kong's banking sector. To our knowledge, no empirical studies have addressed these issues for Macau banking. Using a stochastic frontier approach, Kwan (2006) estimated the cost X-efficiency of 51 Hong Kong banks over the period of 1992 to 1999. Therein, the results suggest that the X-inefficiency in Hong Kong banks was quite large, averaging 16 to 30% of the total costs. In addition, X-efficiency was found to decline over time, which was consistent with technological innovations in the banking industry. Furthermore, the average large bank in Hong Kong appeared to be generally less efficient than average small banks, although the performance gap narrowed over time. Finally, the X-efficiency of Hong Kong banks was found to relate to certain characteristics, including bank size, the ability to make loans and collect deposits, asset quality, and loan growth.

Drake et al. (2006) assessed the relative technical efficiency of various types of banks in Hong Kong over the period of 1995 to 2001 using both the conventional Banker,

Charnes, and Cooper (BCC) approach and Tone's Slacks-Based Model (SBM), in combination with an innovative profit-based DEA specification. The sample set included bank holding companies, commercial banks, investment banks, and non-banking credit institutions. Their results indicate that there were high levels of technical inefficiency in Hong Kong banks. In addition, there was some evidence that suggested considerable variations in efficiency levels and trends across various asset size groups and banking sectors, as well as the differential impacts of environmental factors on different size groups and financial sectors. Finally, the transition to Chinese administration and the Asian Financial Crisis in 1997 did not seem to significantly impact the relative efficiency; however, these findings suggest that the impact of the financial crisis might have been due to adverse developments in the macro-economy and the housing market.

By using Tone's SBM in combination with bootstrapping techniques, Hall et al. (2008) examined the evolution of the efficiency of Hong Kong's banking industry and its macroeconomic determinants over the post-crisis period of 2000 to 2006. Their results suggest that there was a significant negative effect on Hong Kong bank efficiency in 2001, which was probably due to deposit rate deregulation and the adverse financial consequences of the 9/11 terrorist attacks in the US; however, most banks reported a steady increase in efficiency after 2001, and the Severe Acute Respiratory Syndrome epidemic in 2003 did not appreciably impact efficiency. In addition, smaller banks appeared to be more efficient than larger banks, although the latter were able to enjoy economies of scale. Finally, private consumption and housing rent were found to significantly impact bank efficiency.

## **4. Methodology and Data**

### *4.1 Non-parametric estimation methodology*

In the banking literature, there are two separate approaches that can be used to estimate technical efficiency and TFP growth, namely, non-parametric methods, such

as DEA, and parametric methods, such as the stochastic frontier approach (SFA). These two approaches differ in a number of ways. First, non-parametric approaches do not require a priori specifications of a production function, but they also do not incorporate statistical noise. In contrast, parametric approaches confound the effects of any misspecification of functional form but can incorporate statistical noise. Second, non-parametric methods may reveal substantial variations that could be embedded in the data, whereas parametric methods, which usually include a time trend when panel data are available, may smooth the variation of productivity changes over time. Finally, parametric methods necessitate a large sample size in order to make reliable estimations, whereas non-parametric methods are relatively less demanding in terms of data.

Given the small sample size that is employed in this study, DEA, which is a non-parametric approach, is used to estimate input distance function(s).<sup>19</sup> Bank efficiency and productivity changes in Hong Kong and Macau are then calculated and compared.<sup>20</sup> An input distance function measures the maximum amount by which input usage can be radically reduced but still remains feasible so as to produce a given vector of outputs. According to Shephard (1953, 1970), the input distance function is defined as:

$$d(x, y) = \max\{\lambda : (x / \lambda) \in L(y)\}, \quad (1)$$

where the input set  $L(y)$  represents the set of all input vectors  $x$ , which can produce the output vector  $y$ .

Technical efficiency refers to the ability to minimize inputs for a given set of outputs and is calculated under the assumption of variable returns to scale. Therein, it indicates a proportional reduction in input usage if the inputs are not wasted by bank management under the assumption of a current production level, which may be scale

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<sup>19</sup> The econometric software (DEAP2.1) used for DEA in this study was developed and supplied by Professor Tim Coelli, to whom we are grateful.

<sup>20</sup> The details of the DEA linear programming method are provided in Appendix 1.

inefficient. The efficiency score takes a value between 0 and 1 for the worst-practice and best-practice banks, respectively. The change in TFP describes the rate of change of outputs relative to inputs (Fried et al. 1993; Kumbhakar and Lovell, 2000). The Malmquist TFP change index ( $M$ ) is a popular measure of TFP change in the banking literature because it can isolate efforts to catch up to the frontier (i.e., changes in technical efficiency) from shifts in the frontier (i.e., technical change,  $T\Delta$ ). It also allows for the exploration of the primary sources of efficiency change, that is, improvements in management practices (pure technical efficiency change,  $PTE\Delta$ ) or movements toward an optimal size (scale efficiency change,  $SE\Delta$ ). As indicated by Hunter and Timme (1986) and Isik and Hassan (2003), the production frontier may shift upward or downward over time due to innovation (i.e., technical progress), changes in regulatory policies (such as financial liberalization) and market structure (namely, increased competition), and severe financial disruptions and shocks (e.g., financial crises). The equation that can be used to estimate the Malmquist TFP change index is calculated as:

$$\begin{aligned}
M(x^t, y^t, x^{t+1}, y^{t+1}) &= \frac{d_v^{t+1}(x^{t+1}, y^{t+1})}{d_v^t(x^t, y^t)} && (PTE\Delta) \\
&\times \left[ \frac{d_c^{t+1}(x^{t+1}, y^{t+1})/d_v^{t+1}(x^{t+1}, y^{t+1})}{d_c^t(x^t, y^t)/d_v^t(x^t, y^t)} \right] && (SE\Delta) \\
&\times \left[ \frac{d_c^t(x^{t+1}, y^{t+1})}{d_c^{t+1}(x^{t+1}, y^{t+1})} \times \frac{d_c^t(x^t, y^t)}{d_c^{t+1}(x^t, y^t)} \right]^{1/2} && (T\Delta)
\end{aligned} \tag{2}$$

where

- $y$ : output vector
- $x$ : input vector
- $t, t+1$ : two adjacent time periods
- $v$ : variable returns to scale (VRS) technology
- $c$ : constant returns to scale (CRS) technology

Between periods  $t$  and  $t+1$ ,  $M > 1$  implies TFP growth,  $M = 1$  indicates constancy, and  $M < 1$  indicates TFP regression. Similar inequalities are true for  $PTE\Delta$ ,  $SE\Delta$ , and  $T\Delta$ .

## *4.2 Data*

The data are primarily collected from Bankscope, the HKMA, the AMCM, and the annual reports of banks. The resulting data consist of a balanced panel of annual data on major commercial banks in Hong Kong (17) and Macau (14) over the period from 1995 to 2006, totaling 372 observations. The sample banks include licensed banks that are incorporated in Hong Kong and Macau banks that have full licenses. They account for over 90% of the total banking assets in Hong Kong and Macau in 2006. A pool of sample banks from both SARs is used in the estimation. Thus, the obtained results reflect the dispersion of technical efficiency and TFP changes within the entire sample, which make cross-region comparisons more statistically reliable.

This paper employs an intermediation approach to specify outputs and inputs. Inputs include purchased funds, fixed assets, and personnel expenses, whereas outputs consist of total net loans, other earning assets, and non-interest income. Table 2 summarizes the descriptive statistics of the variables that have been used in this study over the aforementioned sampling period. There is substantial variation in the financial characteristics of the sampled banks. On average, Hong Kong banks are considerably larger than those in Macau in terms of both inputs and outputs.

*Table 2 inserted here*

## **5. Empirical Results**

### *5.1 Technical efficiency*

The average technical efficiency of banks in Hong Kong is 0.98, which is only slightly higher, albeit statistically significant, than the average efficiency of 0.97 for banks in Macau during the entire sampling period. Panel A of Chart 1 shows that for the period of 1995 to 2000, Hong Kong banks (0.98) were significantly more efficient over the entire period than Macau banks (0.96). In particular, the transition to Chinese administration and the Asian Financial Crisis in 1997 did not appear to significantly impact the relative efficiency of banks in Hong Kong, which is consistent with the

findings of Drake et al. (2006). In reality, banks in Hong Kong adopted several new strategies to face the challenges that were imposed by the financial crisis. The pressure on revenues meant that they had to pay even more attention to costs; hence, some banks froze their headcounts and some decided to layoff staff and close branches. In addition, banks tried to find ways to more cheaply and efficiently deliver products and services to their customers, for example, through telephone call centers, electronic banking, and the segmentation of branch networks. Banks also put more emphasis on using branch networks to cross-sell other products, such as unit trusts and insurance, to develop non-interest income sources;<sup>21</sup> however, for banks in Macau, the 1997 Asian Financial Crisis markedly deteriorated bank efficiency, wherein the efficiency score decreased from around 0.98 in 1996 to 0.95 in 2000. In addition, bank efficiency in Macau was substantially improved after the transition to Chinese administration in 1999, which increased efficiency to 0.98 in 2001.

*Chart 1 inserted here*

In the period of 2001 to 2006, bank efficiency was quite volatile in both Hong Kong and Macau. The substantial efficiency decline from 2001 to 2002 was primarily due to the global economic downturn. Thanks to the closer relationship with the Mainland due to the ITS, the efficiency of Macau banks sharply rebounded starting in 2002; however, for Hong Kong banks, there is no evidence that shows that they benefited from a closer relationship with the Mainland due to the CEPAs or ITS in terms of bank efficiency. In addition, the results indicate that there was a significant drop in bank efficiency in Hong Kong in 2001. This is consistent with the finding of Hall et al. (2008), who argued that this drop was probably due to deposit rate deregulation and the 9/11 terroristic attack. The lagging effects of the collapse of the Guangdong International Trust and Investment Corporation (GITIC)<sup>22</sup> in 1999 might be another reason for the observed decline. Many Macau banks lent heavily to the GITIC, and,

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<sup>21</sup> Source: HKMA (2010).

<sup>22</sup> GITIC was once one of the most prominent non-bank financial institutions and the second largest trust and investment company in China. It was the investment arm of Guangdong, the fast-growth province bordering Hong Kong and Macau.

therefore, they had to write off a significant portion of bad loans due to the GITIC bankruptcy. The differences in bank efficiency between Hong Kong and Macau might be attributable to the fact that Macau is a relatively much smaller economy with a less developed banking sector in comparison to Hong Kong. Hence, its banking sector is more sensitive to macroeconomic changes, such as the Asian Financial Crisis in 1997, and the liberalization of tourism beginning in 2002. In other words, it seems that Hong Kong banks were better able to adjust their business strategy and improve their performance during the economic downturn but were less able to make exceptional profits from market prosperity due to severe competition.

The sample banks in each market are divided into two groups in terms of asset size. The banks were grouped in this way to investigate (1) whether banks of different sizes exhibit similar efficiency patterns and (2) whether the influences of various events on efficiency are uniform across banks of different sizes. Large banks refer to banks with total assets that are above the mean, whereas the rest are classified as small banks. As can be observed in Panel B of Chart 1, small banks in Macau (0.97) were slightly more efficient on average than their counterparts in Hong Kong (0.96). In contrast, large banks in Hong Kong (0.99) significantly and continuously outperformed large Macau banks (0.96) and small Hong Kong banks (0.96) over the entire sampling period. This pattern of changes in efficiency confirms that both large and small banks in Macau were more sensitive to environmental changes in comparison to their counterparts in Hong Kong.

### *5.2 Malmquist TFP change index*

Table 3 presents the estimated mean annual values of the Malmquist TFP change index and its mutually exclusive components for banks in Hong Kong and Macau over the 1995 to 2006 period. On average, banks in both markets recorded positive TFP growth over the entire sampling period. The productivity of Macau banks grew by 1.7% on average, whereas the annual average TFP growth rate of Hong Kong banks was only 0.8%. The decompositions of both TFP change indices indicate that

technical progress is the key driving force in TFP growth in both regions. Technical innovation allows banks to consolidate back office functions and process transactions across borders so as to optimize cost savings. Likewise, because IT development can be done in any location where the appropriate skills exist, banks can develop their systems and software wherever the productivity advantages are the greatest. This result is consistent with the findings of previous studies concerning Mainland China banking. For example, Yao et al. (2008) found that technical progress and efficiency had approximately the same contributions to TFP growth in Mainland banks. Matthews and Zhang (2009) reported that technical change was the key driver of TFP growth in Mainland banking, except for city commercial banks.

*Table 3 inserted here*

Small banks in Macau (2.7%) outperformed their counterparts in Hong Kong (0.9%), wherein technical progress is the key driving force in both markets. In addition, the average change in efficiency for small banks is negative in Hong Kong (-0.1%) but positive in Macau (0.1%), which implies that small banks in Macau were able to achieve productivity growth through enhanced efficiency measures that were unrelated to technical progress. Turning to large banks, large banks in Macau (1.1%) exhibited faster productivity growth in comparison to their counterparts in Hong Kong (0.7%). Technical progress is the key source of TFP growth in both markets; however, improved technical efficiency (0.1%) is another significant contributor to the TFP growth of large banks in Hong Kong. For large banks in Macau, increased scale efficiency (0.1%) was the other primary source. Finally, small banks in both markets outpaced large banks, and technical progress played a dominant role in the TFP growth of both types of banks.

As is illustrated in Panel A of Chart 2, Macau banking was more volatile than Hong Kong banks in terms of TFP change over the entire sampling period. Particularly, banks in both markets experienced TFP decline during the 1997 Asian Financial Crisis and the global economic downturn in 2001 to 2002, although Macau banking

was more negatively impacted in comparison to Hong Kong banking. The Malmquist TFP change index decreased by 3.6% from 1997 to 1998 and 2.3% from 2001 to 2003 for Hong Kong banks, whereas it decreased by 13.1% and 10.9% for Macau banks in the same two time periods, respectively. In addition, a dramatic TFP growth (25.8%) was observed for Macau banks from 1999 to 2001. This provides evidence to support the fact that the 1999 transition to Chinese administration allowed banks in Macau to operate in a more favorable environment and, hence, to become more financially productive. Furthermore, the sudden decrease in the TFP of banks in Macau after 2001 might be due to the global economic downturn of 2001 to 2002, especially because Macau is an open economy and tourism is its leading industry. Furthermore, the lagging effects of the collapse of the GITIC in 1999 may have also contributed to the observed sudden decrease in TFP. A major turning point for Macau banks came with the end of the casino monopoly<sup>23</sup> in December 2002, which had previously attracted significant foreign capital inflow. A year later, after the Severe Acute Respiratory Syndrome epidemic had subsided, the Chinese central government implemented the ITS. This easing of travel restrictions resulted in a dramatic increase in the number of Mainland visitors, who in turn boosted the economy. In comparison to the banking market in Hong Kong, the Macau banking market remains simpler, smaller, and does not offer complicated investment products. Thus, the performance of Macau banks was more volatile than that of Hong Kong banks; however, the aforementioned factors might have influenced banks in Hong Kong.

*Chart 2 inserted here*

Panel B of Chart 2 shows that the performance of small Macau banks was more volatile than that of large Macau banks and all Hong Kong banks. Particularly, these data imply that the TFP of small Macau banks was more sensitive to environmental changes, such as the 1997 Asian Financial Crisis, the 1999 transition to Chinese

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<sup>23</sup> In 1962, the Macau government granted the Sociedade de Turismo e Diversões de Macau (STDM) the monopoly rights to all forms of gambling in Macau. In 2002, the Macau SAR government ended the monopoly system and 3 casino operating concessions are granted to Sociedade de Jogos de Macau, Wynn Resorts, Las Vegas Sands. (Source: Macau Gaming Inspection and Coordination Bureau, 2010)

administration, the global economic downturn of 2001 to 2002, and the implementation of ITS in 2003. Hence, these small Macau banks primarily experienced TFP growth in two periods, namely, from 1999 to 2002 and from 2003 to 2005. In addition, the TFP change curves for large Macau banks and both large and small Hong Kong banks were quite similar in most years. This finding is not surprising because Hong Kong is an international financial center, and banks in Hong Kong can offer more sophisticated financial products to satisfy the needs of their broader customer base. Large Macau banks could take advantage of their dominant role in the market and keep pace with banks in Hong Kong in terms of TFP change. Thus, their performance was more stable and smooth in comparison to small Macau banks, although their average TFP growth rate was lower than that of the small Macau banks.

## **6. Conclusions**

By employing a DEA approach, this paper is the first to compare technical efficiency and TFP change between the banking sectors in Hong Kong and Macau over the period of 1995 to 2006. The obtained results indicate that the banks in both markets operate at high technical efficiency levels of over 97%, wherein, on average, Hong Kong banks were slightly more efficient than their Macau counterparts. In addition, the 1997 Asian Financial Crisis and the transition to Chinese administration did not appear to significantly impact banks in Hong Kong; however, the technical efficiency of Macau banks significantly decreased after the crisis and then sharply rebounded after the transition to Chinese administration in 1999. Furthermore, the global economic downturn of 2001 to 2002 negatively impacted bank efficiencies in both markets. Macau banks were able to enhance their technical efficiency after the implementation of the ITS by the Mainland government in 2003. Finally, large banks in Hong Kong were the most efficient banks of the two markets, whereas small Macau banks were more efficient on average than small Hong Kong banks.

Regarding bank productivity, the obtained results suggest that banks in both markets, on average, achieved positive TFP growth over the entire sampling period. Technical progress was found to be the key driving force of TFP growth in both regions. In addition, although Macau banks were significantly more productive on average than Hong Kong banks, the productivity growth of Hong Kong banks was more stable and persistent according to a year-by-year analysis. In addition, small banks in Macau achieved the highest productivity growth rate, although their performance was more volatile than other banks in the two regions. Similar to what was observed for Hong Kong banks, the TFP change rate of large Macau banks was more stable than that of small Macau banks. Finally, it appears that the performance of Macau banks was more sensitive to macroeconomic changes than that of Hong Kong banks. The impacts of macroeconomic factors on changes in bank productivity were very similar to their impacts on bank efficiency across both markets.

In general, these findings suggest that banks in Hong Kong and Macau enjoyed a relatively high level of efficiency and a moderate productivity growth over the sampling period. Hong Kong banks outperformed Macau banks in terms of technical efficiency, whereas Macau banks outperformed Hong Kong banks in terms of changes in productivity. There were considerable variations in technical efficiency and productivity across banks with different asset sizes. In addition, the measures that have been adopted by the regulators and bank management to tackle the challenges that have been caused by financial crises and economic downturns have been found to be very effective. In particular, banks in both markets benefitted from a closer relationship with Mainland China because this relationship enhanced their respective performances, especially for Macau banks. Finally, technical growth was the primary reason for TFP growth in banks in both markets. Technological innovations have changed the way banks and their customers interact. Many banks are reconfiguring internal structures to allow customers the ability to access financial services wherever, whenever, and however they wish, as well as improve their performance accordingly.

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**Table 1: Key performance ratios of banks in Hong Kong and Macau**

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
<b>Panel A: Banks in Hong Kong</b>												
% of GDP	NA	7.9	7.5	7.5	8.2	8.4	8.2	8.3	8.5	8.1	8.0	9.6
ROA (%)	1.82	1.78	1.39	0.86	0.94	1.16	1.05	1.18	1.18	1.39	1.40	1.35
Bad debt charge/Total assets (%)	0.08	0.18	0.19	0.60	0.76	0.44	0.40	0.34	0.29	0.02	0.01	0.01
Cost/Income (%)	38.6	37.0	39.5	42.1	39.0	38.1	42.2	39.3	38.6	41.4	41.8	42.7
<b>Panel B: Banks in Macau</b>												
% of GDP	6.8	7.0	7.6	9.4	7.9	8.8	8.2	8.0	7.0	6.1	7.8	8.7
ROA (%)	1.23	1.16	1.05	0.75	0.06	0.54	0.41	0.62	0.63	0.85	1.57	1.65
Bad debt charge/Total assets (%)	0.26	0.21	0.19	0.49	0.95	0.85	0.83	0.68	0.58	0.31	0.18	0.10
Cost/Income (%)	52.92	51.48	61.45	56.77	52.68	49.27	44.69	42.92	37.56	36.79	35.23	33.05

Sources: Hong Kong Census and Statistics Department, HKMA Annual Report (various issues), Macau Statistics and Census Service, AMCM Annual Report (various issues).

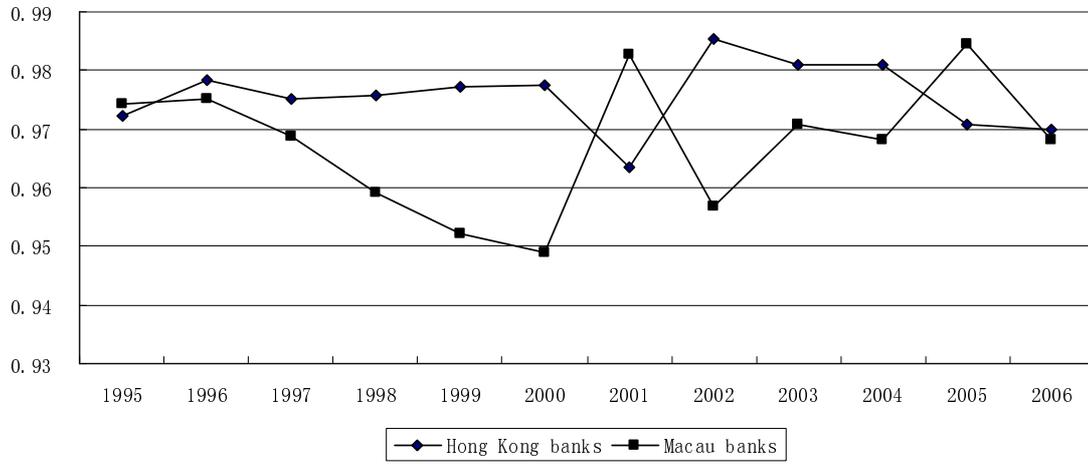
**Table 2: Summary statistics**

	<b>Mean</b>	<b>Standard deviation</b>	<b>Maximum</b>	<b>Minimum</b>
<b>Panel A: All sample banks</b>				
<i>Inputs</i>				
Purchased funds	106056.28	321397.59	3056846.88	261.14
Fixed assets	2834.99	7990.30	53332.08	0.03
Personnel expenses	763.90	2464.47	23316.43	0.40
<i>Outputs</i>				
Total net loans	54820.74	150610.50	1156604.40	0.11
Other earning assets	56992.05	181948.34	1875545.38	69.05
Non-interest income	1160.57	4277.54	44852.16	1.05
<b>Panel B: Hong Kong</b>				
<i>Inputs</i>				
Purchased funds	187060.25	417254.74	3056846.88	7001.68
Fixed assets	5068.58	10274.13	53332.08	53.61
Personnel expenses	1353.44	3213.11	23316.43	73.02
<i>Outputs</i>				
Total net loans	97413.55	193407.07	1156604.40	4977.74
Other earning assets	100156.93	237326.69	1875545.38	2065.68
Non-interest income	2048.64	5627.59	44852.16	40.34
<b>Panel C: Macau</b>				
<i>Inputs</i>				
Purchased funds	7694.32	9901.61	48070.42	261.14
Fixed assets	122.76	166.43	681.10	0.03
Personnel expenses	48.03	55.71	285.46	0.40
<i>Outputs</i>				
Total net loans	3100.91	3970.49	18379.22	0.11
Other earning assets	4577.55	6300.31	36617.78	69.05
Non-interest income	82.20	136.53	1151.05	1.05

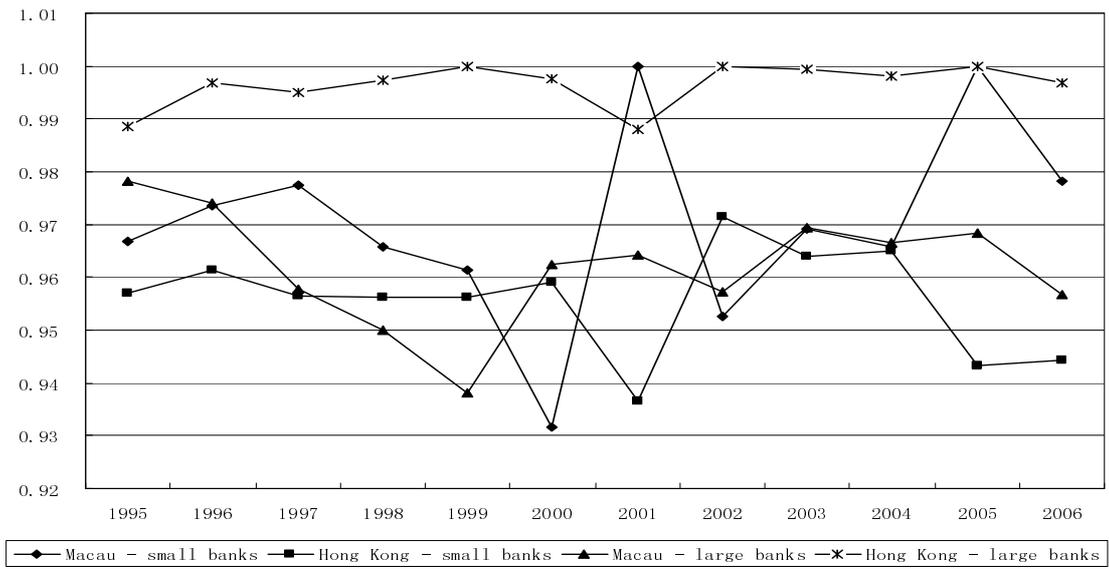
Note: All financial data are expressed in constant 2002 prices using individual-region GDP deflators and then reported in million HK dollars using the exchange rate of HKD100=MOP103.

**Chart 1: Technical efficiency (1995 to 2006)**

*Panel A: All sample banks*



*Panel B: Small vs. Large banks*



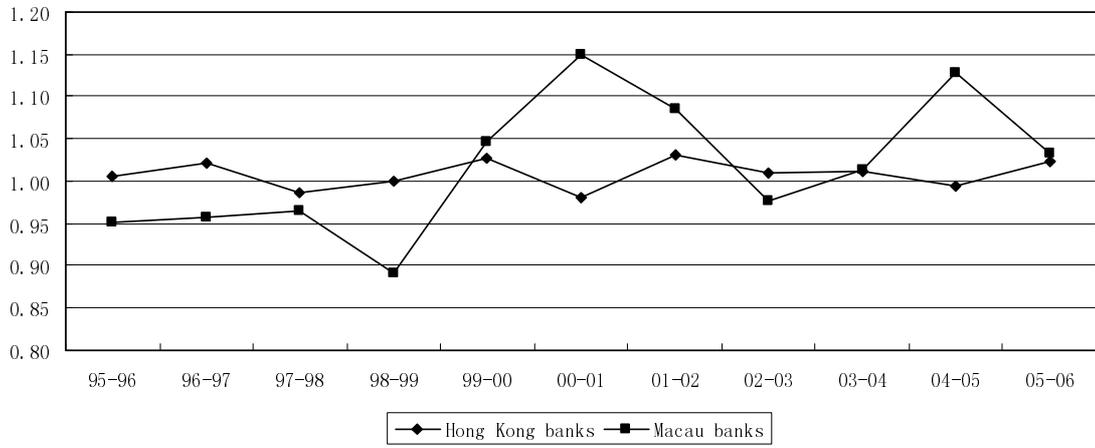
**Table 3: Malmquist TFP change index (1995 to 2006)**

	Hong Kong	Macau
<b>Panel A: All banks</b>		
Malmquist TFP change index	1.008	1.017
T $\Delta$	1.009	1.018
PTE $\Delta$	1.000	1.000
SE $\Delta$	0.999	0.999
<b>Panel B: Small banks</b>		
Malmquist TFP change index	1.009	1.027
T $\Delta$	1.011	1.026
PTE $\Delta$	0.999	1.001
SE $\Delta$	0.999	0.998
<b>Panel C: Large banks</b>		
Malmquist TFP change index	1.006	1.010
T $\Delta$	1.007	1.011
PTE $\Delta$	1.001	0.998
SE $\Delta$	0.999	1.001

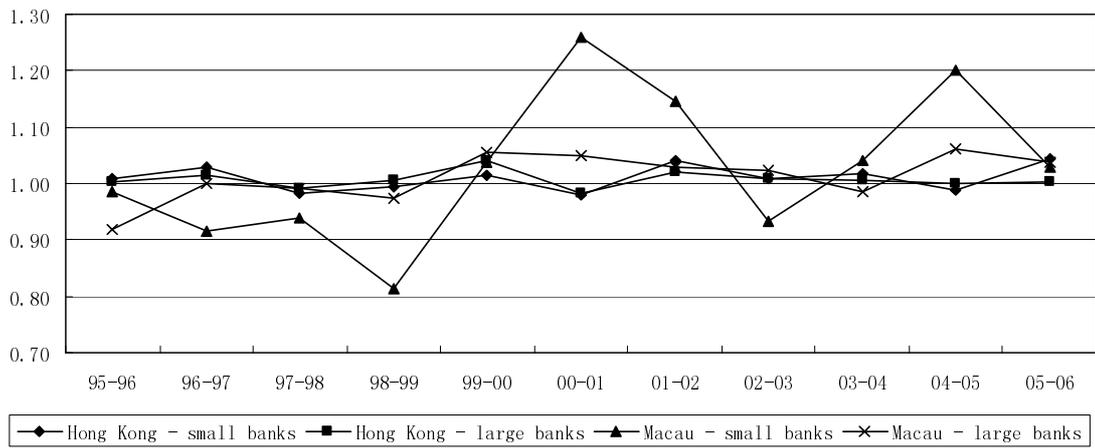
Notes: Malmquist TFP change index =  $T\Delta * PTE\Delta * SE\Delta$ , where  $T\Delta$  denotes technical change,  $PTE\Delta$  denotes pure efficiency change, and  $SE\Delta$  denotes scale efficiency change.

**Chart 2: Malmquist TFP change index (1995 to 2006)**

*Panel A: All sample banks*



*Panel B: Small vs. Large banks*



## Appendix 1: DEA linear programming method

In order to compute the Malmquist TFP change index of bank  $i$  between  $t$  and  $t+1$  based on Equation (2), it is necessary to solve four different sets of linear programming (LP) problems as follows:

$$\left[ d^t(x^{i,t}, y^{i,t}) \right]^{-1} = \min \theta \quad (3)$$

s.t.

$$y_m^{i,t} \leq \sum_{i=1}^I y_m^{i,t} \lambda^{i,t}, \quad m = 1, \dots, M$$

$$\theta x_n^{i,t} \geq \sum_{i=1}^I x_n^{i,t} \lambda^{i,t}, \quad n = 1, \dots, N$$

$$\lambda^{i,t} \geq 0, \quad i = 1, \dots, I$$

The computation of  $d^{t+1}(x^{i,t+1}, y^{i,t+1})$  is exactly like LP(3), where  $t+1$  is substituted for  $t$ . Two of the distance functions used to construct the Malmquist index require information from two different periods. One of these is computed for bank  $i$  as:

$$\left[ d^t(x^{i,t+1}, y^{i,t+1}) \right]^{-1} = \min \theta \quad (4)$$

s.t.

$$y_m^{i,t+1} \leq \sum_{i=1}^I y_m^{i,t} \lambda^{i,t}, \quad m = 1, \dots, M$$

$$\theta x_n^{i,t+1} \geq \sum_{i=1}^I x_n^{i,t} \lambda^{i,t}, \quad n = 1, \dots, N$$

$$\lambda^{i,t} \geq 0, \quad i = 1, \dots, I$$

The computation of  $d^{t+1}(x^{i,t}, y^{i,t})$  is exactly like LP(4), where  $t+1$  is substituted for  $t$ .

In order to decompose the technical efficiency change measure into a scale efficiency measure and a “pure” technical efficiency measure (refer to Equation 2), two additional linear programming problems should be solved for. These would involve repeating the computation of  $d^t(x^{i,t}, y^{i,t})$  and  $d^{t+1}(x^{i,t+1}, y^{i,t+1})$  with the convexity restriction ( $\sum \lambda^i = 1$ ) added to each. It provides estimates of distance functions relative to a variable returns to scale technology. For details, please see Berg et al. (1992), Grosskopf (1993), and Coelli et al. (2005).