TOTAL FACTOR PRODUCTIVITY ANALYSIS OF THE WATER SERVICES INDUSTRY IN MALAYSIA

GOH KIM HUAT

UNIVERSITI SAINS MALAYSIA

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TOTAL FACTOR PRODUCTIVITY ANALYSIS OF THE WATER SERVICES INDUSTRY IN MALAYSIA

by

GOH KIM HUAT

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LIST OF ABBREVIATIONS

CPI	Consumer Price Index
CRS	Constant Return to Scale
DDF	Directional Distance Function
DEA	Data Envelopment Analysis
DMUs	Decision Making Units
FE	Fixed Effect
FTE	Full-Time Equivalents
GDP	Gross Domestic Product
LPI	Luenberger Productivity Indicator
LSDV	Least Square Dummy Variable
MLPI	Malmquist Luenberger Productivity Index
MPI	Malmquist Productivity Index
MWA	Malaysia Water Association
MWIG	Malaysia Water Industry Guide
MWSI	Malaysian Water Services Industry
NRW	Non-Revenue Water
NWRC	National Water Resources Council
NWSC	National Water Service Commission
OLS	Ordinary Least Square
OPEX	Operating Expenditure
PAAB	Pengurusan Aset Air Berhad
RE	Random Effect
SFA	Stochastic Frontier Analysis
SPANA	Suruhanjaya Perkhidmatan Air Negara Act
TFP	Total Factor Productivity
VIF	Variance Inflation Factor
VRS	Variable Return to Scale
WaSCs	Water and Sewage Companies
WG	Within-Group
WSIA	Water Services Industry Act

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ANALISIS PRODUKTIVITI FAKTOR KESELURUHAN BAGI INDUSTRI PERKHIDMATAN AIR DI MALAYSIA

ABSTRAK

Reformasi industri perkhidmatan air telah menarik minat dalam kalangan penyelidik bagi menjalankan penilaian analisis produktiviti factor keseluruhan industri. Di Malaysia, kerajaan persekutuan telah mengambil usaha untuk menjalankan reformasi industri perkhidmatan air untuk mengatasi masalah kewangan dan "non-revenue water". Pelbagai initiatif dan regulasi telah dilaksanakan bagi meningkatkan produktiviti industri perkhidmatan air. Akan tetapi, terdapat kajian yang terhad telah dijalankan bagi menilai kesan reformasi terhadap produktiviti industri tersebut. Dengan ini, kajian ini bertujuan untuk menjalankan analisis kadar pertumbuhan produktiviti faktor keseluruhan industri perkhidmatan air sebelum dan selepas reformasi industri dari 2000 hingga 2017. Khususnya, kajian ini menggunakan "bootstrap Malmquist Luenberger productivity index" dengan mengintegrasikan "non-revenue water" dalam model. Tambahan itu, kajian ini akan menentukan komponen yang menyumbangkan kadar pertumbuhan produktiviti bagi 14 pengendali air sebelum dan selepas reformasi industri. Kajian ini juga mengenalpasti lima pembolehubah, iaitu: tempoh reformasi, densiti pelanggan, penggunaan air domestik, kos pengeluaran, dan air simpanan margin, untuk menerangkan kadar perubahan produktiviti industri perkhidmatan air. Hasil kajian menunjukkan bahawa industri tersebut mengalami penurunan kadar perubahan productiviti sebanyak 0.57 peratus disebabkan oleh kemerosotan perubahan teknologi pada kadar 1.05 peratus. Kebanyakan pengendali air telah menghadapi masalah kemerosotan perubahan teknologi akan mengalami penurunan produktiviti selepas reformasi. Hasil kajian ini juga menegaskan bahawa

tempoh reformasi, kos pengeluaran, dan air simpanan margin berkorelasi negatif dengan perubahan produktiviti. Reformasi industri mamainkan peranan penting; namun begitu, ia tidak mencukupi untuk menambahbaik keseluruhan prestasi industri. Secara konklusi, pihak kerajaan dan pengawal selia perkhidmatan air memainkan peranan penting bagi mengkaji semula dasar-dasar sedia ada dalam reformasi industri di Malaysia. Penggunaan kaedah kuantitatif tersebut bagi analisis produktiviti faktor keseluruhan industri telah meningkatkan pemahaman yang lebih lanjut mengenai prestasi semasa industri tersebut berkait dengan isu-isu reformasi industri perkhidmatan air di Malaysia.

TOTAL FACTOR PRODUCTIVITY ANALYSIS OF THE WATER SERVICES INDUSTRY IN MALAYSIA

ABSTRACT

The interest in evaluating the total factor productivity of the water services industry has increased following the regulatory reform of the industry. In Malaysia, a visionary effort has been taken by the federal government on restructuring the water services industry to ensure its financial viability of water operators and to address the non-revenue water (NRW). Multitudes of initiatives as well as regulations have been introduced and implemented for the improvement of the water services industry productivity. However, there is lacking of studies conducted to assess the impact of the regulatory reform to the water services industry productivity. Therefore, the main objective of this study is to evaluate the total factor productivity (TFP) change in the water services industry in Malaysia before and after the regulatory reform. The study applies the bootstrap Malmquist Luenberger productivity index and integrates the undesirable output of NRW for the Malaysian water services industry. This study also aims to determine the drivers contributing to the TFP change in the 14 water operators before and after the regulatory reform. Moreover, this study is first attempt to capture five explanatory variables (regulatory reforms, customer density, domestic water consumption, production cost, and reserve margin) as determinants to explain the variation of productivity change in the industry. The results confirmed that during the study period, the industry experienced a deterioration in the average productivity of 0.57%, which is mainly attributed to the technical regression that occurred at an annual rate of 1.05%. At the water operator level, the water operators that exhibited a greater magnitude of technical regression tended to experience a negative productivity value changes following the regulatory reforms. The results also showed that regulatory reforms, production costs, and reserve margin are negatively correlated with productivity change. Reforms are essential but insufficient to improve the industry productivity. Thus, the government and water regulators should revise the existing policies and redefine the regulatory reforms of the water services industry. The use of advanced quantitative approaches to analyse the water services industry in Malaysia calls for a better understanding of the TFP change in the industry related to the key issues of regulatory reform.

CHAPTER 1

INTRODUCTION

1.1 Introduction

In the past decades, infrastructure industries such as telecommunications, electricity, water and sewage, and railways have traditionally been public sector responsibilities (Estache et al., 2006). The public sector usually operates in monopoly regimes, and these industries have not given much attention to productivity analysis. In general, the monopoly market structure has been adopted worldwide due to the cost advantages incurred when a single company provides a service in certain regions rather than involving several companies (Nauges and Van Den Berg, 2007). In the case of the water services industry, the operational activities (water production, water treatment, and water distribution) are primarily managed by public ownership in monopoly environments, and there is a lack of incentives to improve their efficiency and productivity (Marques et al., 2016). The water services industry has experienced several fundamental problems that occur worldwide, such as the following: asymmetric information (Laffont, 2005), effects of externalities (Molinos-Senante et al., 2010), scale and scope of economies (Carvalho and Marques, 2014), and public service obligation (Marques et al., 2011). Without adequate regulation of the industry, this situation is expected to worsen with the growing water demand, environmental degradation (Mikulik and Babina, 2009), and financial gaps faced by public and private water operators (Marques et al., 2011). In this context, the industry requires regulatory reform that includes a broad range of regulations and the introduction of an independent regulator (Pinto et al., 2017).

As part of the regulatory reform in the water services industry, privatization has generally been adopted in developed countries. Over the last decade, the privatization and regulatory reform of the industry have been matters of public debate. A successful privatization and regulatory reform implementation requires a clear definition for both water operators and the public regarding what the regulator aims to achieve to improve industry productivity (Byatt, 2013). Privatization has served as a good example of reform in developed countries and has attracted attention worldwide since the first water services industry in England and Wales was completely privatized in 1987 (Molinos-Senante et al., 2017a). The regulatory framework design must be strongly associated with privatization to enhance the economic performance of the water services industry (Stern and Holder, 1999). The rationale for privatization is introduced through fiscal and efficiency hypotheses (Ouda et al., 2014). The financial constraints of the industry can be addressed by involving the private sector (fiscal hypothesis), and it is believed that the private sector is more technically efficient than the public sector in this industry (efficiency hypothesis). However, privatization is not guaranteed to provide good accessibility, affordability, and service quality to water customers (Estache et al., 2006). The unbundling of services could lead to the risk of loss in terms of coordination and economic scope, in which the more lucrative parts of the water system (water treatment) belong to the private sector, while the less profitable parts of the water system (water distribution) remain under public ownership (Estache and Fay, 2007).

At the earlier phase of the privatization and regulatory reform process, no complete guidelines have been published on how to improve the economic performance of the water services industry in terms of efficiency and productivity (Abbott et al., 2009). Instead of restructuring the institutional and regulatory capacities (see Tan, 2012 for an explanation of why these initiatives are not drivers for development), stimulating the competition across the water utilities is viewed as the only way to enhance the productivity of the industry. In doing so, benchmarking analysis is a quantitative technique used to compare the efficiency and productivity among water utilities (Marques and De Witte, 2010). In addition, efficiency analysis and total factor productivity (TFP) analysis are two popular benchmarking tools that have been the focus of researchers over the past two decades (Berg and Marques, 2011). TFP can be used to measure industry productivity based on the change in aggregate outputs quantities produced relative to the change in aggregate input quantities consumed, as long as the sample period and the assumptions regarding the production technology are well defined (Marques, 2008b). To the best of the author's knowledge, Saal and Parker (2001) were the first to conduct a TFP analysis of the water services industry in England and Wales. TFP analysis is technically important for both developed and developing countries; with TFP analysis, the decision-making units (DMUs) or water utilities allow for an assessment of whether better productivity is delivered and can help identify the worst performers (De Witte and Marques, 2012). The debate regarding the impact of the regulatory reform and the productivity of the water services industry has gained considerable attention because it has long been an issue in the design of regulatory frameworks.

Improving the productivity of the industry is essential to ensure that it provides better quality water services to customers. Additionally, it is important to set water tariffs to ensure the long-term sustainable growth of the industry (Sala-Garrido et al. 2018). In the future, water demand is expected to increase due to the rapid growth of the world population and industrial activities. Ensuring good accessibility to and sustainability of the clean water supply is essential because it represents one of the

Sustainable Development Goals established by the United Nations (UN, 2015). On a whole, improving the TFP is one of the main focuses when formulating regulatory frameworks for the water services industry (Molinos-Senante et al., 2017b).

1.2 Research Background

After Malaysia's independence in 1957, the operational activities of the water services industry were the responsibility of state governments (or public ownership) in Malaysia. The state government managed the industry through the Public Works Department, which provides consultation work, technical support, and water project management based on funding provided by the Malaysian federal government (Ching, 2012). Water coverage is defined by the states in Malaysia, in which each state is served by a single water operator (MWA, 2018). For instance, the operational activities of the water operator in Johor, which range from water production to water distribution, are fully managed by Ranhill SAJ Sdn. Bhd. However, the water operators in Malaysia faced different sets of regulations and inconsistent work cultures, leading to imbalanced productivity changes at the company level. Regulatory mechanisms such as water incentives and subsidies on the total water consumption levels, have been promoted to improve industry productivity; however, they lead water customers to access larger proportions of water from areas with lower water tariffs (Ching, 2012). Hence, it is difficult for the industry to achieve full-cost recovery through long-term industry growth. As noted in Tan (2012), economic decisions regarding water operators have been influenced by political interventions. For instance, state governments may use public funds to subsidize the revenue losses of the operators (Auriol and Picard, 2009; Martimort and Straub, 2009), or the governments may use the water tariff adjustment as an agenda to attract political support. Hence, privatization was introduced in 1987 to resolve the shortcomings in the regulatory framework of the industry and to allow it to catch up to the rapid economic growth in Malaysia.

The privatization of the water services industry is viewed as one of the ways to stimulate the competitive environment to improve the productivity of the industry and meet the increasing water demand over time (Anwandter and Ozuna, 2002). The ownership statuses of water operators are categorized as public, private, corporatized[1], and public-private[2], as depicted in Table 1.1. In certain cases, the ownership structure in private, corporatized and public-private partnerships is classified as private ownership. This practice is not appropriate and could be misleading in regard to the productivity assessment. In fact, only the water operator in Johor has fully privatized water production, water treatment, and water distribution activities.

Several water operators in Kelantan, Pulau Pinang, and Terengganu have been corporatized in 2000, and the number of corporatized water operators has been increasing since 2017, as shown in Table 1.1. Labuan serves the smallest population with the smallest state area, followed by Perlis and Pulau Pinang. Sarawak has the largest total state area and serves the largest populations. It is important to highlight the inaccuracy of the hypothesis that those companies that serve the smallest areas are more efficient and productive. In fact, the water operator in Sarawak, Pahang, Perlis, and Labuan were performed positive change in TFP in Malaysia (See and Ma, 2018).

[1] Corporatized water operators are managed under the responsibility of state governments, as they are the major shareholders. However, their functions operate at arm's length with different degrees of managerial autonomy (McDonald, 2016).

[2] The public-private structure refers to the model in which the operational activities of water operators are managed by state governments with private involvement. There is a relationship between state governments (sponsoring authority) and private firms (which legally have more than 50% of the equity shares) in the infrastructure management during the concession period. The infrastructure is procured by private operators during the concession period and will be taken over by state governments after the end of the contracts (Trebilcock and Rosenstock, 2015).

It is a popular belief that industry productivity will improve with private involvement. Following the evidence provided by Saad and Harun (2017), the productivity of the Malaysian water services industry (MWSI) increased partly because of the budget support received from the Malaysian federal government in the 10th Malaysia Plan during the years 2000 to 2007. Lee et al. (2014) also highlighted that the industry had an increase in managerial efficiency of 0.8% between the years 1999 and 2008. However, privatization later created some failures in the competitive market, which occurred for several reasons. For instance, the non-revenue water (NRW) is reported to be relatively high in Malaysia. NRW is defined as the difference between the water input volume and the water sold as a proportion of the water input volume. Figure 1.1 shows the components of NRW in the water services industry. Initially, raw water is abstracted, treated by water operators and delivered to customers through water pipelines. The NRW occurs as the result of apparent losses and real losses throughout the water delivery processes. The apparent losses are due to inappropriate water metering, while the real losses are due to water leakage that occurs in ageing water pipes, particularly in the asbestos cement pipes that are still widely used for water distribution in Malaysia. The components of apparent losses, real losses and unbilled authorized consumption are grouped as the components of NRW. The financial sustainability of those water operators experiencing a higher percentage of NRW will be affected, thus leading to inefficiency.

Table 1.1 Ownership structures for the state of water services companies in Malaysia.

State	Ownership in year 2000	Ownership in year 2010	Ownership in year 2017	Population served (in thousand person)[2]	Total area (cu.m)[2]
Johor	Private (Ranhill SAJ S/B)	Private (Ranhill SAJ S/B)	Private (Ranhill SAJ S/B)	3912.95	19161.21
Kedah*	Public (Jabatan Bekalan Air Kedah)	Public-private (Syarikat Air Darul Aman S/B)	Public-private (Syarikat Air Darul Aman S/B)	2409.09	9532.28
Labuan	Public (Jabatan Bekalan Air Labuan)	Public (Jabatan Bekalan Air Labuan)	Public (Jabatan Bekalan Air Labuan)	104.24	90.93
Melaka*	Public (Perbadanan Air Melaka)	Corporatized (Syarikat Air Melaka Berhad)	Corporatized (Syarikat Air Melaka Berhad)	901.28	1664.05
Negeri Sembilan*	Public (Jabatan Bekalan Air N. Sembilan)	Public-private (Syarikat Air N. Sembilan S/B)	Public-private (Syarikat Air N. Sembilan S/B)	1295.15	6708.89
Pahang*	Public (Jabatan Bekalan Air Pahang)	Public (Jabatan Bekalan Air Pahang)	Corporatized (Pengurusan Air Pahang Berhad)	1750.85	35885.37
Perlis*	Public (Jabatan Kerja Raya Perlis)	Public (Jabatan Kerja Raya Perlis)	Corporatized (Syarikat Air Perlis S/B)	319.14	820.17
Sarawak[1]	Public (Jabatan Kerja Raya Sarawak)	Public (Jabatan Kerja Raya Sarawak)	Public (Jabatan Bekalan Air Luar Bandar Sarawak)	3368.28	122930.00
Kelantan	Corporatized (Air Kelantan S/B)	Corporatized (Air Kelantan S/B)	Corporatized (Air Kelantan S/B)	1146.05	15051.85

Table 1.1 Ownership structures for the state of water services companies in Malaysia (Cont.).

State	Ownership in year 2000	Ownership in year 2010	Ownership in year 2017	Population served (num)[2]	Total area (cu.m)[2]
Pulau Pinang	Corporatized (Perbadanan Bekalan Air Pulau Pinang)	Corporatized (Perbadanan Bekalan Air Pulau Pinang)	Corporatized (Perbadanan Bekalan Air Pulau Pinang)	1738.75	1048.15
Terengganu	Corporatized (Syarikat Air Terengganu S/B)	Corporatized (Syarikat Air Terengganu S/B)	Corporatized (Syarikat Air Terengganu S/B)	1252.50	13046.88
Perak	Public-private (Lembaga Air Perak)	Public-private (Lembaga Air Perak)	Public-private (Lembaga Air Perak)	2845.43	21116.36
Sabah	Public-private (Jabatan Air Negeri Sabah)	Public-private (Jabatan Air Negeri Sabah)	Public-private (Jabatan Air Negeri Sabah)	2990.74	72240.00
Selangor	Public-private (Syarikat Bekalan Air Selangor S/B)	Public-private (Pengurusan Air Selangor S/B)	Public-private (Pengurusan Air Selangor S/B)	8429.19	8400.29

Notes: P.Pinang = Pulau Pinang, N. Sembilan = Negeri Sembilan, S/B = Sendirian Berhad. Asterisk (*) indicates the state of the water services companies changed their ownership status after the regulatory reform is introduced in 2006. The parentheses are the name of the company in the state.

[1]Includes the province of Sarawak, Kuching, Sibu, and LAKU. There are four water agencies in Sarawak, that are: Jabatan Bekalan Air Luar Bandar Sarawak, Kuching Water Board, Sibu Water Board, and LAKU Management Sdn. Bhd.

[2]The data is based on the year 2017 and extracted from Malaysia Water Industry Guide (MWA,2018).

Source: Compiled by author from the company background in various websites.

Figure 1.1: Components of non-revenue water.
Source: Openintl (2017).

Following See and Ma (2014), the NRW has significantly negatively influenced the productivity change in the water services industry in Malaysia, contributing to a deterioration in productivity of 0.72%. Ageing water pipelines and infrastructures, which were built before Malaysia's independence in 1957, have been observed in many areas. Technology innovation and infrastructure development involve large investment costs, and these funds mainly come from the federal government. Addressing NRW is a difficult and complicated task in which the different causes of NRW need to be managed, and collaboration with various stakeholders is needed (Frauendorfer and Liemberger, 2010). Therefore, the Malaysian federal government called for regulatory reform in 2006, and as an initiative for reducing the NRW, they introduced financing mechanisms for the water services industry (Teo, 2014).

The regulatory reform was introduced in conjunction with the establishment of two new legal acts, i.e., the Water Services Industry Act (WSIA) and the Suruhanjaya Perkhidmatan Air Negara Act (SPANA). Regulatory bodies were also created, such as the National Water Services Commission (NWSC), Pengurusan Aset Air Berhad (PAAB), and the National Water Resources Council (NWRC), along with the development of water corporations. The functions defined in the legal acts and the responsibilities of the regulatory bodies will be discussed in the subsequent chapter. One of the key thrusts in the regulatory reform is the proposition of the asset light model by PAAB (Teo, 2014). In the asset light model, the ownership of infrastructures and water assets are transferred to PAAB, which is fully owned by the Ministry of Finance Incorporated. The development and maintenance of these infrastructures and water assets are fully managed by PAAB and leased to the water operators at affordable rental rates (Lai et al., 2020). As such, the water operators are focused only on operational activities directed towards water treatment and water provision. The progress of the regulatory reform, which encompasses a series of regulations, has provided new directions for the water services industry towards a successful path.

1.3 Problem Statement

The water operators in Malaysia were characterized by poor financial statuses, underinvestment of capital, and high water loss levels in distribution. The industry's productivity was declining, as the NRW adversely affected the TFP change in the water services industry. Though the financial system remained instable for infrastructure development and there was a relatively higher percentage of NRW, the regulatory reform began in 2006 to address these issues. Such regulatory frameworks in terms of legal and institutional outcomes include the asset light model and establishment of the NWSC with two legal acts, i.e., the WSIA and SPANA, etc. The regulatory reform, which is composed of a range of regulations, has received good feedback from the public. Hence, it is necessary to evaluate whether the regulatory reform contributes to the TFP change in the MWSI. Though the impact of regulatory reform on industry productivity has been examined by empirical studies in different countries, the studies are still less robust in the case of Malaysia. Different views exist regarding the productivity assessment of the MWSI, and the limitation of the previous studies is that the samples of the MWSI are assessed directly without considering the impact of the regulatory reform on the industry productivity.

Notable attention was given to the environmental-friendliness and sustainability of the water services industry worldwide. The undesirable output resulting from the unintended consequence of the output production has been widely explored in recent studies. The study of the relationship between undesirable outputs and the productivity of the water services industry is especially important. In developing countries, including Malaysia, the production process from water production to the water delivered entails undesirable outputs, such as NRW. The water services industry has been stressed from the increasing operating and infrastructure costs stemming from NRW. Moreover, when coping with NRW and investment costs, the water services industry could be affected in terms of the water service quality and sustainability according to the production theory, where "minimum inputs for maximum outputs" is promoted. Ignoring the undesirable outputs in the productivity assessment is tenuous when designing regulatory frameworks.

Despite the regulatory reform that began in 2006 in Malaysia, the relationship between the reform and the productivity of the water operators remains unclear. The ownership status of the water operators, which can be categorized as public, fully private, corporatized and public-private operators, is complicated during the reform period. As each of the water operators consumes different water resources and has different levels of capital, productivity assessments allow the water operators to determine whether it has best or worst productivity through the productivity drivers. Hence, the best practises of the water operators should be used as a benchmark to improve the productivity of the worst performing water operators.

Finally, as mentioned, the water operators in Malaysia have different social and physical characteristics, including economies of scale, production costs and water reserve margins, and there are no two water operators managed in the same operational environment. The inclusion of explanatory variables (or environmental variables) determines the possible improvement in the productivity of MWSI, although in general, the declining productivity is due to the high percentage of NRW and escalating infrastructure costs. Although several studies have been conducted to assess the productivity the water services industry in Malaysia, to the best of the author's knowledge, no attempt has been made to identify the explanatory variables of the industry productivity change. Hence, a study examining the relationship between environmental variables and the TFP change in MWSI is timely.

1.4 Research Questions

This study proposes to address the following research questions:

i. What is the impact of the regulatory reform on the TFP change in the water services industry in Malaysia while incorporating the undesirable outputs?

ii. How do the drivers (efficiency change and technical change) contribute to the TFP change at the water operator level before and after the regulatory reform?

iii. What are the potential explanatory variables that influence the TFP change in the water services industry in Malaysia?

1.5 Objectives of the Study

Based on the research questions, the objectives of the study are outlined as follows:

i. To access the TFP change in the water services industry in Malaysia before and after regulatory reform while incorporating the undesirable outputs.

ii. To determine the drivers of the TFP change in the 14 water operators before and after the regulatory reform.

iii. To identify the potential explanatory variables influencing the productivity change in the water service industry.

1.6 Significance of the Study

Although there are empirical studies found to evaluate the TFP change in the water services industry in Malaysia, the impact of the regulatory reform in the industry has not been explored while accounting for the NRW as undesirable outputs in the productivity evaluation. In this context, this study contributes to the literature by evaluating the TFP change in the water services industry before and after the regulatory reform. First, the study serves as a reference to provide significant information to water operators, water regulator, and policy makers that can aid in designing the regulatory framework associated with addressing the NRW.

Second, this study also reveals the components contributing to the TFP change in the water operators before and after the implementation of the regulatory reform. This could reveal whether the water operators are achieving better productivity through the application of a combination of technologies. Additionally, the findings would identify the productivity drivers, which could provide a target when attempting to achieve future productivity improvements. There is a public debate on whether the regulatory reform is effective in improving the productivity of the water operators; thus, water operator best practices should be benchmarked to help other water operators improve their productivity.

Finally, the study also reveals the impact of explanatory variables on the TFP change in the water services industry. Water operators with different characteristics could be affected differently due to external factors, such as regulatory reform, customer density, domestic water consumption, production costs, and reserve margins. This is accounted for by using static panel data econometric models that incorporate heterogeneity. The technique adds to the scientific knowledge of the researchers by including the role of explanatory variables as the determinants to the TFP change in the water services industry.

1.7 Scope of the Study

The current study included 14 water operators in Malaysia; the information was extracted from the Malaysia Water Industry Guide (MWIG) reports, and the Malaysian sewage industry was not included in the study. The MWIG reports are published by a collaboration between the Malaysia Water Association (MWA), the water regulator and other government bodies, such as Ministry of Water, Land, and Natural Resources and water supply divisions. The data in the MWIG reports were collected from all the state water supply entities, and the information provided in the MWIG reports is comprehensive, including operational indicators, financial indicators, services quality and tariff rates (Lee et al., 2014). A total sample of 14 water operators were included in the study from 2000 to 2017 – two publicly owned operators, one that is fully privatized, six corporatized operators, and five that have public-private partnerships. Five input variables were selected for the productivity measurement, as follows: treatment plant design capacity, length of pipelines, employees in executive positions, employees in non-executive positions, and other operating inputs. Meanwhile, the volume of water delivered, and water lost in distribution are considered as the desirable output and undesirable output, respectively. Subsequently, a dummy variable for regulatory reform, as well as the customer density, domestic water consumption, production cost, and reserve margin, are included as the environmental variables to explain the productivity change variation in the water services industry in Malaysia.

1.8 Research Process

To measure the TFP change in the MWSI before and after the regulatory reform, the Malmquist Luenberger productivity index (MLPI) is applied in this study for the 14 water operators while incorporating the NRW as the undesirable output between the years 2000 and 2017, as shown in Figure 1.2. Additionally, this study also determines which factors are contributing to the TFP change among water operators in Malaysia. In general, assessments based on the price index, data envelopment analysis, the partial and TFP index, and stochastic frontier analysis have been used to evaluate the TFP change in the water services industry worldwide.

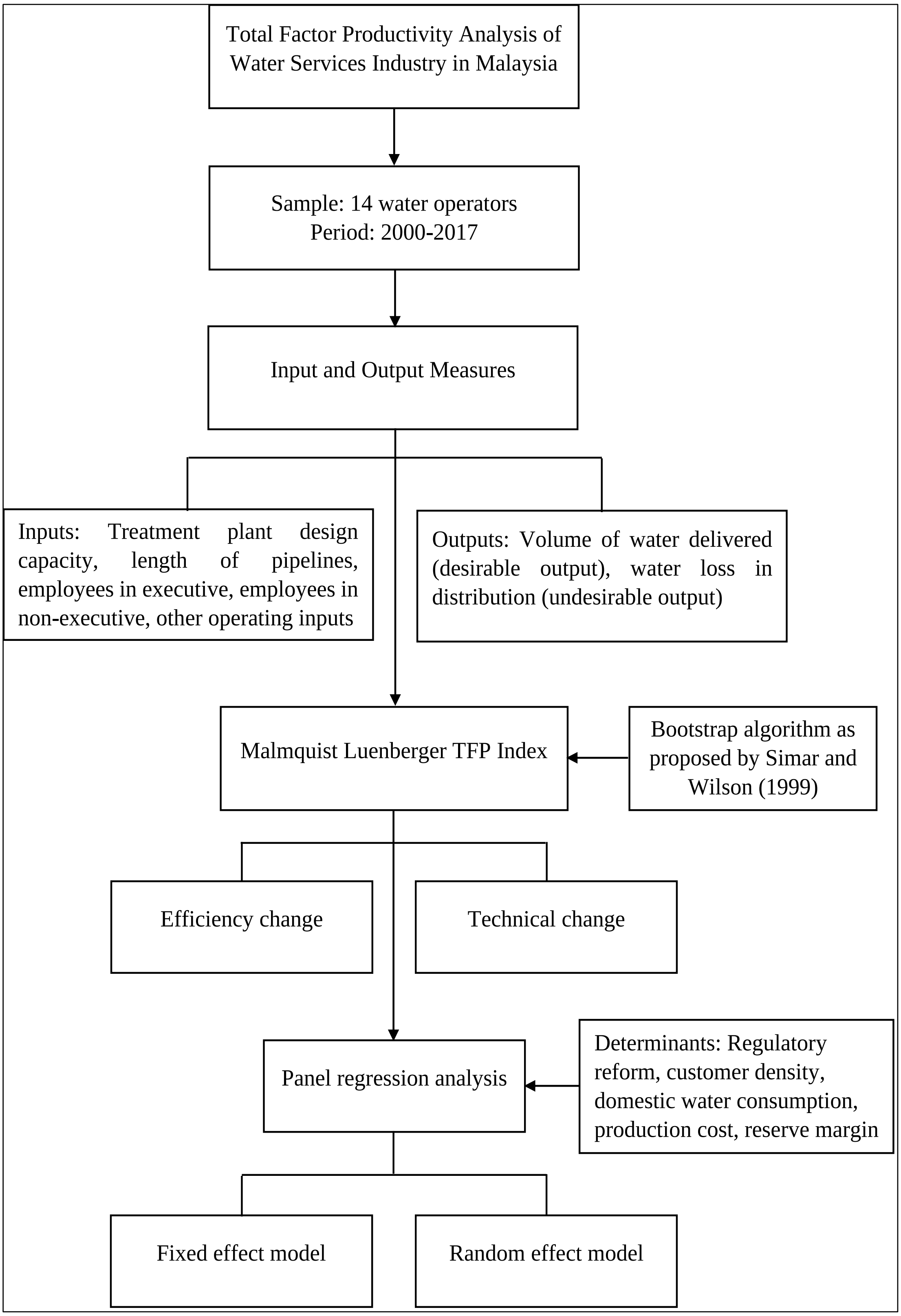


Figure 1.2: Research framework.

There are two popular benchmarking approaches, i.e., data envelopment analysis (DEA) and stochastic frontier analysis (SFA), that have been widely used in recent years to evaluate the TFP change in the water services industry (Zhang et al., 2016). DEA is a non-parametric linear programming method used to determine the efficiency and TFP change in homogeneous DMUs (Charnes et al., 1978). DEA is usually applicable to the public sector under several conditions in which the market is distorted by regulated tariffs, subsidies and a lack of a competitive structure (Abbott et al., 2012). Alternatively, the parametric technique of SFA has also been applied to identify the inefficiency component and deal with the error term (Coelli et al., 1998).

There are three main advantages of DEA, as follows: (i) a priori assumptions for the functional form are not necessary for the production process; (ii) DEA allows for computation of the productivity of DMUs that involve multiple inputs to produce multiple outputs; and (iii) the shares to aggregate inputs and outputs are generated endogenously (Cooper et al., 2011). However, there are several major shortcomings in the DEA approach, which are related to its deterministic nature. First, it does not consider noise effect, and the productivity obtained is sensitive to data errors due to a lack of robustness verification (De Witte and Marques, 2010a). Second, statistical inference cannot be obtained from the DEA models (Bădin et al., 2014).

To overcome these limitations, Simar and Wilson (1999) proposed the bootstrap approach, which allows for robustness and statistical inferences, to resolve the statistical limitation of the conventional DEA framework. To the best of the author's knowledge, only two studies (Ananda and Hampf, 2015; Ananda and Pawsey, 2019) have adopted the bootstrap MLPI for bias-correction of the productivity change in recent years. Simar and Wilson (2007) also proposed a double-bootstrap approach for the bias-corrected results for an efficiency score. Thus, this study employs the bootstrap algorithm for obtaining the bias-correction of TFP change in the MWSI. After the productivity change has been estimated, static panel regressions (fixed effect and random effect models) are applied to determine the explanatory variables that influence the TFP change in the industry. Hypothetical testing is then employed to determine the most appropriate panel regression in the study. Diagnostic checks are essential and are required to examine the outlying observations in the analysis.

1.9 Thesis Structure

The thesis is organized as follows: Chapter 2 discusses the outcomes of the regulatory reform and describes the input and output variables of the water services industry in Malaysia, as well as the potential explanatory variables influencing the productivity change in the industry. The theoretical frameworks on efficiency and productivity change, empirical studies on the productivity changes in the industry in developed and developing countries, reviews on input and output variables, and the explanatory variables are discussed in Chapter 3. The productivity framework used to evaluate the TFP change in the water services industry in Malaysia and the methodological framework used to identify the explanatory variables of the productivity change are presented in Chapter 4. Chapter 5 presents and discusses the results of the study. Chapter 6 ends with the policy implications in terms of improving the regulatory reform, the contributions of the study, limitations and suggestions for future studies.

CHAPTER 2

WATER SERVICES INDUSTRY IN MALAYSIA

2.1 Introduction

In general, this chapter provides an overview of the water services industry in Malaysia. The chapter is divided into 5 sections, starting with Section 2.2, which explains the legal and institutional outcomes of the regulatory reform. Section 2.3 presents a brief introduction of the inputs and outputs of the water services industry. Section 2.4 describes the information and statistics of the explanatory variables. The last section summarizes the chapter.

2.2 Outcomes of the Regulatory Reform

The regulatory reform of the Malaysian water services industry (MWSI) was introduced in 2006. The procedure for restructuring the industry by the Malaysian federal government is to ensure that the industry continues to deliver clean water to the customers and promote long-term financial sustainability growth as well as addressing the non-revenue water (NRW) issue. The outcomes of the regulatory reform are categorized into legal and institutional. The two main legal outcomes are the introduction of two acts: Water Services Industry Act (WSIA), and Suruhanjaya Perkhidmatan Air Negara Act (SPANA). Meanwhile, the institutional outcomes consist of National Water Service Commission (NWSC), Pengurusan Aset Air Berhad (PAAB), water corporation, and National Water Resources Council (NWRC).

2.2.1 Legal Outcomes of the Regulatory Reform

WSIA was enforced in January 2008 with the central authority, NWSC. It focuses on regulating the water services industry. The main principle of the WSIA is to establish a regulatory framework and new licensing so as to promote the national objectives of the water services industry (MEWC, 2006b). A standardized regulatory framework is implemented by providing licenses to all the water operators. The new licenses are uniform in terms of the regulation and requirements, which are subjected to the national objectives of the industry. Before the regulatory reform, the state governments had imposed a different set of regulations and objectives for its water operators. There are three types of licensing provision in WSIA which are issued to a business entity, namely individual license, class license, and facilities license. An individual license serves to undertake the water services provided by operating public water supply system. A class license is required to provide the water supply using private water supply system. The facilities licensees are provided to the public and private water operators which own the water supply systems.

The commencement of SPANA in the year 2006 saw the establishment of NWSC. SPANA provides NWSC the authority to regulate and supervise the water services companies, as well as to implement the laws of those services (MEWC, 2006a). This act provides a list of goals and terms of the NWSC, which define the roles and responsibilities of the NWSC in terms of memberships, finances, functions, and water resources regulations. The laws of the water operators have to be redefined by the state governments so as to design a better framework for water resources sustainability. Both acts (WSIA and SPANA) aim to provide a guideline for constructing a well-regulated industry that is able to resolve several issues, including NRW and conflict of interest of jurisdictions among shareholders.

2.2.2 Institutional Outcomes of the Regulatory Reform

NWSC was established in 2007 to implement the industrial policy according to the guidance of WSIA. The main focus of the NWSC is to regulate all the water operators based on the WSIA 2006, from the process of water treatment to the disposal of wastewater in transparent and effective ways. The vision of the NWSC is to ensure that the quality of water provisions is sustainable, reliable, and affordable for everyone. SPANA 2006 summarises a plan describing the four main functions of this commission: (i) to provide the government a guidance in accordance with the national policy objectives of the water services industry laws; (ii) to impose and implement the water services industry laws and promote the regulatory reform; (iii) to improve the industry productivity and monitor the operational activities according to the laws and standard guidelines and; (iv) to increase the efficiency change of the industry by reducing the NRW through a comprehensive program and to ensure good water services quality for the customers. The national policy objectives must be well-interpreted to deliver accurate information to the water services industry.

Additionally, NWSC has added amendments to Act 654 and Act 655 in 2017 to resolve the limitations of the policy which were resulted from the changes in economic conditions over the period as well as the unclear definitions of the amendments in the acts (KeTTHA, 2017). Besides, an appropriate tariff mechanism was also promoted by the NWSC for the industry to achieve full-cost recovery and protect the property right of the shareholders and customers. In the current economic and political situations, neither below-cost tariff nor upper-cost tariff would affect the shareholders and water consumers (Ching, 2012).

The second institutional outcome is the establishment of PAAB, a company which is wholly managed by the Ministry of Finance. The main objective of the PAAB is to solve the financial gaps between the water operators and to improve the financial sustainable growth of the industry. The asset light model, one of the keys thrust of the reform was implemented by PAAB after the regulatory reform 2006. In the asset-light model, all the ownership of infrastructures and water assets, such as treatment plants and water pipelines are under the responsibility of PAAB, while the water operators mainly focus on providing clean water to the customers without any financial concerns. Regulating water infrastructures and assets is essential to prevent intervention from any third parties or other associations. When the water operators facing any financial constraints during their operational activities, they can request financial aid by submitting a 30-year master plan and a 3-year business plan to PAAB and NWSC. The processes of reviewing plan objectives and the amount of funding are required to ensure that the water operators utilise the fund effectively.

The third institutional outcome is the transformation to the corporatized water companies. Before the regulatory reform was implemented, the roles in the regulation and operational activities were performed by state governments. This transformation is an initiative to replace the roles of the state governments and to improve the productivity which is related to the operating activities and financial sustainability. The working cultures of the private water operators are implemented through the corporatization. Under the corporatization, the government issues standardized licenses and requirements, as mentioned in the WSIA 2006, to private companies. The license is relevant to the uniform regulation and national objectives that need to be complied by all the water operators. During the process of corporatization, the operators are allowed to continue their operational activities within cooling period.

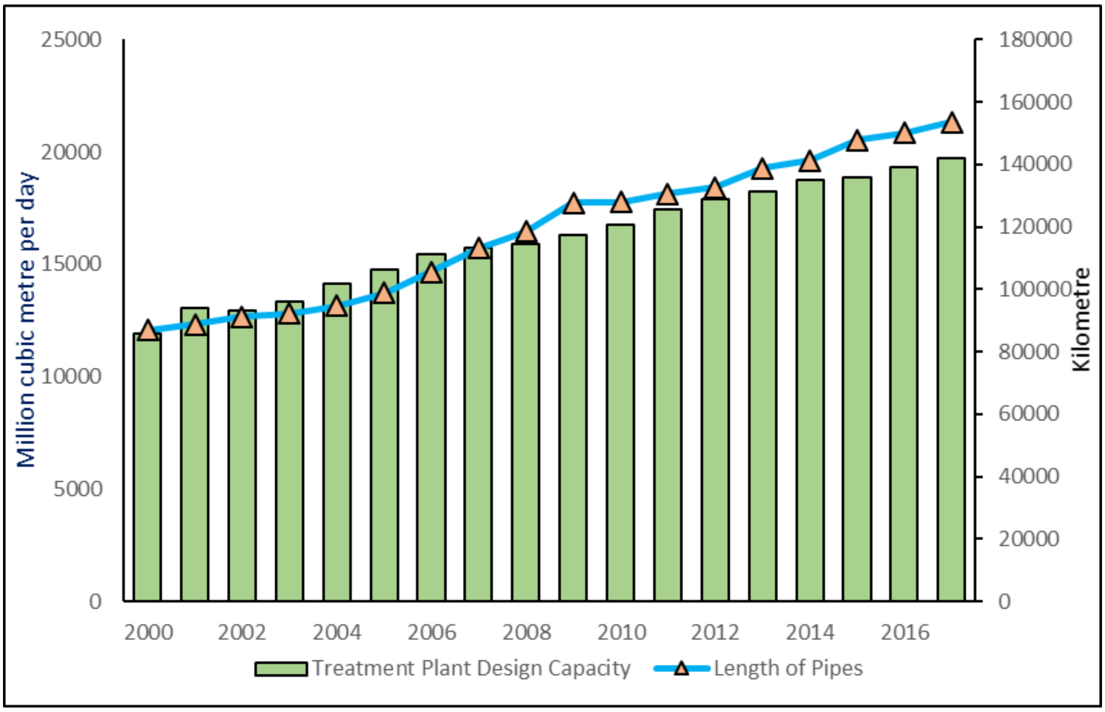
The last institutional outcome of the regulatory reform is the introduction of the NWRC. This council plays the roles of conserving the water resources and protecting the environments in Malaysia. The vision of the NWRC is to ensure that the water resources are handled efficiently and effectively in terms of their quality and quantities so as to meet the water demand of Malaysian customers. NWRC was established at the state levels before the implementation of the regulatory reform in the year 1998. However, this body was important and continued its operation during the period of regulatory reform. The industry could be sustained in the long-term growth if the industry operates in relation to green technology and well-management in the water resources. Malaysia has been facing climate change in recent years that has led to water pollutions and flood. The state governments were urged to adopt the rainwater harvesting systems, advanced water leak detection tools, controlling NRW, and to improve storage equipment (KeTTHA, 2017).

2.3 Inputs and Outputs of the Water Services Industry in Malaysia

The combination of inputs and outputs in production are important when evaluating the productivity change in the water services industry. The input variables represent the input consumed by the water operators that reflect the effectiveness in terms of resource usage and management. Resources such as capital, employees and operating inputs are important internal factors that are under the control of the water operators. The output variables can represent services for supplying water to the customers and the quality of water services. The volume of water delivered and the percentage of NRW are the outputs that could affect the financial sustainability of the water operators. The study will discuss these variables to obtain a clear picture of these variables in the water services industry in Malaysia.

2.3.1 Treatment Plant Design Capacity and Length of Pipelines

Private water operators are responsible for managing water production and water treatment; water distribution, on the other hand, is handled by the public water operators (Tan, 2012). During the regulatory reform period, PAAB controlled the infrastructures and water assets, such as treatment plants and water pipelines. Improving the treatment plant design capacity and increasing the length of pipelines are the full responsibilities of PAAB. Figure 2.1 illustrates the treatment plant design capacity and length of the pipelines in Malaysia from 2000 to 2017. Such an improvement required a large amount of funding, which was fully supported by grants from the federal government. To ensure every customer has access to water, the federal government decided to focus on increasing the length of the pipelines, as mentioned in the Malaysia Plans, to provide equitable water to the rural areas.



Notes: the measurement unit for length of pipelines is kilometres (km) and treatment plant design capacity is million cubic metre per day.

Figure 2.1: Malaysian water services industry: treatment plant design capacity and length of pipelines from 2000 to 2017.

Sources: Malaysia Water Association (MWA) (2001-2018).

2.3.2 Number of Employees in the Water Services Industry

The total number of employees performing operational activities for the water services industry is measured based on full-time equivalent (FTE) employees. Figure 2.2 shows the FTE staff employed in the water services industry between the years 2016 and 2017. It is observed that the water operator in Selangor has employed the highest number of water services staff. The greater water demand in Selangor associated with the high population density and industrial consumption required skilled employees in the water services industry. In addition, the number of staff employed in 2017 for the 6 water operators in Johor, Labuan, Pulau Pinang, Perak, Sabah, and Terengganu was lower than the number of staff employed in 2016. There is an implicit assumption that the skill level of employees is similar across water operators. These employees can be further decomposed into several types of groups, such as employees in executive position and non-executive position (MWA, 2018).

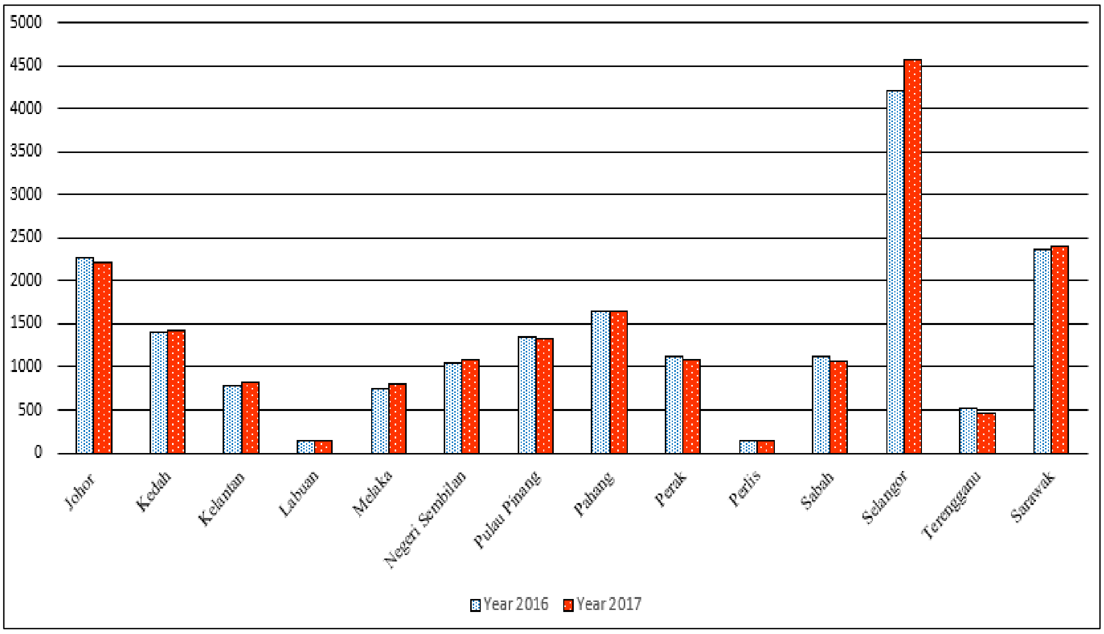


Figure 2.2: Staff employed in 2016 and 2017.
Sources: MWA (2017-2018).