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Essays on the Risks and Returns of Water Investments

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Abstract

Water is a vital commodity; essential to life, agriculture and industry. The water industry is one of the largest industries in the world, and is continuously expanding. Humans have been facing substantial water scarcity, especially those in developing countries. However, the severe water stress is not primarily a result of the lack of water resources, but surprisingly, a product of financial underinvestment. Researchers tackle this problem with water mainly from a policymaking perspective, and the driving force of private investments – profit – has been ignored. Hence, there is a need to examine the water industry from the point of view of risks and returns.

To fill this gap, the thesis conducts three studies. The first study investigates the profitability and diversification effect of water investments. Value at Risk and Conditional Value at Risk are estimated for optimal risky portfolios. The results indicate that the water asset class outperforms the traditional asset classes (stocks and bonds), and has the capacity to produce diversification effects in portfolios primarily comprised of listed equity and bond assets. To further understand the factors associated with expected returns, the second study investigates the impact of asset liquidity risk on water companies' stock returns. This study adopts the ratio of fixed asset to total asset as a measurement of asset liquidity and uses panel data analysis to examine the relationship between returns and asset liquidity, beta, size and book-to-market ratio, as well as the joint explanatory power of these variables. The results suggest that asset illiquidity is positively associated with stock returns. Specifically, water firms with a larger proportion of illiquid assets-in-place are observed to have greater stock returns than those with a smaller proportion of illiquidity assets. The

third study explores the impact of regulatory announcements on the systematic risk of water businesses using a two-step procedure. First, employing the Kalman Filter procedure, the time-vary betas are estimated based on the Capital Asset Pricing Model. Then, further tests for the impact of regulatory intervention risk on water companies are conducted by regressing betas on different types of regulation announcement events. The results demonstrate that water investors view certain types of regulatory changes as being effective on the industry's systematic risk; however, these effects may not be transferrable at an individual company level.

The thesis has both theoretical and practical implications. Its findings provide further empirical evidence on the important role of illiquidity risk and regulatory risk in asset pricing models particularly if these models are applied in the analysis of industries which involve infrastructure. It supports the notion that the systematic risk portrayed in the capital asset pricing model should be modified and allowed to vary over time. It sheds light on investment management and public policy. It reassures water investors that consistent with the investment community's common belief, water assets are valuable additions and can be included as an alternative investment asset class in their portfolios. It highlights that if private sector investors are to be involved, policy makers must recognise that these investors do expect to be compensated for the illiquidity and regulatory risks, in addition to other non-diversifiable investment risks, that are inherent in the water industry. Moreover, it cautions policy makers to be aware of the potential outcomes of their actions. Lastly, the thesis points out possible directions for future research.

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Statement of Originality

This work has not previously been submitted for a degree or diploma in any university.

To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

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Statement of Contribution of Co-authors

Included in this thesis are papers in *Chapters 3, 4, 5 and 6* which are co-authored with other researchers. Yizheng Jin is the lead author of all published and unpublished chapters of this dissertation and completed the majority of the creative, scholarly, and clerical work that constitutes the research output. Yizheng Jin's contribution to each co-authored paper is outlined at the front of the relevant chapter. The bibliographic details for these papers including all authors, are:

- Jin, Y., Li, B., Roca, E., & Wong, V. (2014). Investment returns in the water industry: a survey. *International Journal of Water*, 8(2), 183–199. doi: 10.1504/IJW.2014.060965
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- Jin, Y., Roca, E., Li, B., & Wong, V. (Under Revision). Water as an investment: Liquid yet illiquid! *Applied Economics Incorporating Applied Financial Economics*.
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For the two papers that are published in the *International Journal of Water* – ‘Investment returns in the water industry: a survey’ and ‘Sprinkle your investment portfolio with water!’, the Journal permits the Author to use his article elsewhere, after the date of its publication in the Journal, in other works or for the purposes of the

Author's teaching and research upon condition that it shall not be accessible until six (6) months after publication by Inderscience.

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Chapter 1 Introduction

This chapter provides an overview of the current problems confronting the water sector, the possible reasons underlying these problems and the prospective future of the water industry. It aims to promote an understanding of the background and motivation of this thesis. Moreover, it illustrates the significance of the research, theoretical foundation, research questions and methodology.

1.1. Overview of the Water Industry and Water Investments

Water is a vital commodity; essential to life, agriculture and industry. It should be readily accessible to all humans. However, due to population expansion, economic development and poor management, such needs are not always met. The world's need for large quantity and high quality water has reached its peak – more than 2.6 billion people are living in areas affected by severe water stress (Organisation for Economic Co-operation and Development; OECD, 2008). Distressingly, these numbers are still growing. In response to these challenges, the United Nation's Millennium Development Goals (MDG) identifies water supply and sanitation services as key factors in lifting people out of poverty (Tremolet, Cardone, Silva, & Fonseca, 2007). The OECD countries have also actively sought to develop and manage their water systems (Wild, Francke, Menzli, & Schon, 2007).

The water industry is believed to be one of the three largest industries in the world (along with Oil & Gas and Electricity) in terms of embedded capital (Summit Global Management, 2012). Although there is no consensus on the size of water market, it is clear that the global water industry is enormous. The German company Siemens announces that the global water industry is worth \$400 billion a year when it acquires US Filter from Veolia in 2004. White et al. (2010) report that the world's market for water-related equipment and operation is more than \$480 billion in 2010, while Summit Global Management (2012) estimates the number to be near \$700 billion per year. In contrast, in the same year, the world's IT market is \$650 billion, the Cell Phone market is \$600 billion, Pharmaceuticals are \$450 billion, and Telecom Equipment is \$300 billion (White et al., 2010). However, the financial crisis of 2008 has caused a dramatic economic downturn for water sector, with weak residential and commercial construction markets, delays in large infrastructure projects and a decline in industrial production (Wild, Buffle & Hafner-Cai, 2010). Against this backdrop, White et al. (2010) report that the world's market for water-related equipment and operation is \$483 billion in 2010, and the number is confirmed by Wild et al. (2010).

1.1.1. *Water Shortage and Its Associated Problems*

The importance of water cannot be overemphasised as life on earth would be impossible without it. Human bodies consist of approximately 60 per cent of water and nearly everything we manufacture or grow must be supported by the use of water. Sufficient water

of adequate quality is essential for the productivity of various business sectors – food and beverages, manufacturing, mining, energy and so on. (OECD, 2009a).

Water covers about two-thirds of the earth's surface. It is a resource that exists so commonly on this planet that many people tend to take its availability for granted. However, only a very small fraction of it is freshwater suitable for consumption by human beings. Among the limited freshwater reserves, only one per cent that is found in lakes and ground is directly useable by humans (Wild et al., 2007). According to Pinsent Mason (2010), a law firm specialising in water, there is still sufficient freshwater in the world and water should not be a significant problem for modern societies if both freshwater supplies and humanity were distributed evenly across the world. It is argued that the mismatching of water supplies with regions of need is the root of the problem of water shortage (Pinsent Mason, 2010).

The OECD (2008) indicates that the problem of water scarcity will worsen over time as a result of climate change, unsustainable use and poor management of water resources. Population growth and urbanisation are placing further pressure on water shortage. The number of people living in areas affected by severe water stress is project to climb from current more than 2.6 billion to over 3.9 billion by 2030 (OECD, 2008). In many developing countries the increase of water-related infrastructures is falling behind the growth of population (Tremolet et al., 2007). According to Tremolet et al. (2007), many people are forced to rely on unsafe, inconvenient services from water vendors. For those with a piped

connection a large proportion could only access water for a few hours a day and the sanitation of the water is questionable. The inadequacy of water infrastructure appears to be a major obstacle to achieving the Millennium Development Goals of halving the urban population without access to safe and sanitary water (OECD, 2007b; The World Bank, 2009).

The costs of inadequate provision of safe water are tremendous: families spend a large fraction of household expenses purchasing water from vendors; 500 million people get affected by illnesses each year because of poor water supplies and sewerage; some 60,000 people die every day due to waterborne diseases and environmental impairment (Pinsent Masons, 2010). The world has witnessed increasing pressure, competition and even conflicts in some regions over the use of water resources (OECD, 2009b). Furthermore, water-related problems have been jeopardising developing countries' endeavouring on projects such as poverty alleviation, health, hunger and education (OECD, 2009a).

1.1.2. *Financing Gaps*

Considering that the earth is mostly covered by water and the fact that water will not disappear from the planet because of over usage, water resources are not scarce in an absolute sense. The scarcity of water becomes a real issue when it comes to the availability of affordable, sanitary fresh water. Most water-related problems can be resolved by the application of modern technology given that adequate economic development and capital supporting are in place (Ben-Ami, 2010). Hence, it is reasonable to argue that the water

problems in modern societies are largely money issues and that the lack of financial resources is directly related to the shortage of fresh water supply around the world.

The water industry is known to be capital intensive where a large amount of funds are required to establish water systems and to provide for previously under-served populations. As water infrastructures depreciate over time, more money needs to be spent on maintaining and upgrading existing systems. According to a comprehensive review carried out by the World Health Organization, USD 72 billion per year are required to achieve the MDG targets for water supply and sanitation demands in developing countries (Hutton & Bartram, 2008). The developed countries, with established water systems, are also facing significant financial challenges modernising aging water infrastructures to comply with higher environmental standards and to redeem the underinvestment of earlier years (OECD, 2009c). Moreover, the annual capital cost of developing water infrastructures in OECD countries and BRICs is likely to amount to USD 800-1,000 billion per year by 2030 (OECD, 2006).

Substantial financing gaps exist between the supplies and demands of water-related investments. Toubkiss and Jeremie (2006, as cited in OECD, 2009b) claim that water service investments in developing countries are required to be doubled in order to reach the MDG targets for water. Later, the OECD (2009b) points out that this figure may be an underestimation as it omitted the maintenance expenses. The financial situation may be less challenging in the developed world, but more investments are still required. For instance,

France and the United Kingdom need to increase their spending on water by 20% in order to maintain water services at the current level, while Japan and Korea need to expand these investments by more than 40%. For the United States, the Environmental Protection Agency has estimated that USD 23 billion per year will be needed on water infrastructures to meet the regulations of water institutions (OECD, 2009b).

The water sector has been relying on public subsidies and for developing countries transfers from the Official Development Assistance (ODA) as well. In most OECD countries, though user tariffs and earmarked taxes are collected to fund water-related infrastructures, government spending is still one of the main funding sources (OECD, 2009b). For developing countries, while they are supported by ODAs from OECD countries every year, only about 5% of the ODA money is used for water funding purpose and the percentage has not increased since the year of 2000 (Pinsent Masons, 2010; Tremolet et al., 2007). The problem with relying on funding from the public sector is that their resources are very limited and the competition for them is intense. As the world is facing water problems worse than ever, traditional approaches to finance the water sector alone are not sufficient in meeting these challenges.

Owing to insufficient funding from public sector, innovative financing solutions have emerged to encourage private financial resources flowing into the water sector over the recent year (OECD, 2009a). Privatisation is increasingly believed to be the most efficient way in

dealing with water shortage. Despite the lack of agreement on the best forms of private sector participation, municipalities over the world have endeavoured to increase privatisation of water sector through various forms such as asset sales, concession contracts and lease contracts.

Private runners benefit the societies by developing and bringing new financial resources into the water sector. They commoditise water so that funding can be collected and made available for improving water services. According to the World Bank (2009), 24 million people benefitted from new connections through 36 major water private sector participation projects. Apart from bringing new entries, private sector mobilises extant assets to optimise their efficiency. Pinsent Masons (2010) estimates that privatising water and sewerage services will reduce capital spending by 20-45% and service provision costs by 10-25%. Operating expenditures have also been cut down following private sector's participation. Till 2007, 721 million people, that is, 11% of the world's population are utilising private water or sewerage services. The figure is expected to increase to 1,161 million by 2015 and to 1,538 million by 2025 (Pinsent Masons, 2010).

1.1.3. *Problems in Water Privatization*

Unfortunately, the privatization of water sector is not progressing as smoothly as expected. The difficult situation is largely attributable to the poor understanding of the risks and returns involved in the water industry. Profit incentives drive private investors to make

investment decisions. The main question in making an investment decision is whether or not appropriate risk premiums can be earned in response to the risks borne. At a different level, the importance of water sector requires government institutions to manage and monitor its business environment and profitability of water companies (The World Bank, 2006). Hence, both private participators and government agencies need an accurate estimation of the risk-adjusted returns, in order to determine whether the return is insufficient or exploitative (Buckland & Fraser, 2001).

However, limited research has been done in this area and the nature of water industry is under-investigated. The industry remains ill-defined and poorly understood by the general investing public when compared to other more traditional and widely-followed sectors of the global economy (Maxwell, 2009). The lack of such a common acknowledgement jeopardises private sector participation in this field. For instance, many arrangements for private participation in water services have been cancelled, or at least run into trouble, as either operators or government institutions (or both) believed that the arrangement have not been fairly implemented (The World Bank, 2006). Accurate estimations of risk and return of business involved in the water sector is urgently called for.

1.1.4. *Liquidity Risk and Regulatory Risk in Water Investments*

There are two types of risks involved in water investments – liquidity risk and regulatory risk. These risks make the water market complex, resulting in detriment of

commercial financing. UNEP Finance Initiative (2006) lists several water-related risks in their report – *Financing water: risk and opportunities*. It claims that water companies/investments are exposed to a high level of liquidity risk because first, the industry is capital intensive. It is even more capital intensive than other infrastructure industries such as electricity and telecommunication. Second, the investments required to provide the services are often long-lived. Third, the investments cannot be readily converted into cash. Moreover, once the investments are made, they cannot be reversed should the returns to the investment prove less than expected (The World Bank, 2006). According to financial theories, if the liquidity risk is unable to be diversified away, then investors in the industry should earn a risk premium. Therefore, one of the main concerns in making water investment decisions is about whether an appropriate risk premium is earned, given the lack of liquidity.

In addition, UNEP Finance Initiative (2006) also emphasises regulatory risk as a determinant of the performance of water industry. A key notion underlying the privatisation of water sector is the belief that water is an economic good (Savenije, 2002). Yet, water is more complex than a pure economic good. On the basis of excludability and rivalry, economists have identified four types of economic goods: private, public, club goods and common pool resources (Lopes, 2005). Freshwater in its natural setting is non-rivalry and non-excludable, for every individual can access it and the consumption of water by one person will not reduce its availability to others. Hence, it is not surprising that water is conventionally considered as a public good. In the modern world, there is growing

recognition of the importance of water; in 1992, the United Nations stated the right of all human beings having access to clean water and sanitation services at an affordable price. The strong link between water services and politics makes water a political public good or a social good (Schouten & Schwartz, 2006).

The provision of water as a public good involves numerous interest groups and stakeholders, including powerful suppliers, consumers and municipal governments and groups such as private service providers (Schouten & Schwartz, 2006). Different interest groups guard and promote their interests and compete for favourable regulation. Although water suppliers are influential over regulations, unorganised interest groups such as consumers and citizens may still be well-represented in the political process owing to their voting power (Denzau & Munger, 1986). As a result, investing in a public good such as water supply and sanitation is not only a question of calculating the economic cost-benefit ratio, but understanding how it is intertwined with a political realm (Schouten & Schwartz, 2006).

Trade-offs between water investors and governments tend to expose investors to a high level of political uncertainty. This is because firstly, water is a massively consumed output; both interest groups and politicians are concerned about the pricing of water and governmental regulations. This can be seen in a number of cases where poor performance or excessive prices raised consumers' resentment, which prompts political decisions to terminate operating contracts (Lobina & Hall, 2003). Secondly, water sector is characterised

of scale and scope. Companies in this sector involve large, specific, sunk investments, and most water projects have a long life (typically 25-30 years). Over such long periods, the political operating environment is likely to change (e.g., because of changes in national policy) and contracts may not be flexible enough to accommodate subsequent adjustments (OECD, 2009b). Risk arises when there is a likelihood of politicians intervening to override the terms of agreed contracts, or to exploit ambiguities in them. This is particular likely to happen at the completion of an investment programme, when tariff increases are due (OECD, 2009b). Thus, it is widely acknowledged that water investors are exposed to a high level of political risk (The World Bank, 2006).

1.2. Research Overview

1.2.1. Research Problem and Objectives

The water industry is one of the largest industries in the world. Water experts estimate the size of the global water industry today to be between USD 425 billion and USD 700 billion per year, while the numbers are poised for considerable growth (Geman & Kanynda, 2007). Nevertheless, this does not alter the fact that water industries continue to suffer from the problem of underinvestment; there have been large financing gaps in the water industries of both developing and OECD countries. Wild et al. (2007) argue that it is the financing gaps that lead to insufficiency of water infrastructure and serve as an important contributing factor to global water shortage.

Due to insufficient funding from public sectors, innovative financing solutions have emerged to encourage private funding to enter the water industries over the past two decades (OECD, 2009). The great needs for funding as well as a good prospect of growth make water industry a hot space. There has been an increasing interest in the concept of investing in the water market, which government institutions inspire to nurture in order to alleviate the stress of water shortage.

Different from products such as oil, wheat and metal, water is not usually traded on the market as a commodity. Hence, investing in water-related projects and companies has been the most commonly adopted approach alternate to direct investment. In this context, water stocks, water funds and water indices are regarded as the best vehicles for investors who are interested in this market.

Interestingly, few investment institutions have placed their research focus on water industry. Research on the profitability of water investments is generally lacking. Investors are ill-informed about the performance of water stocks as well as the determinants of their prices. This becomes a barrier to attracting private investments, which is urgently needed by the water sectors. Therefore, a thorough examination of the risks and returns on water investments would contribute to our knowledge on the pricing of water stocks and profitability of investing in a water sector. The present research would benefit water investors by helping them systematically understand the risks and benefits of water investments. In

addition, such knowledge would also be of interest to policy makers and advisers by aiding them design arrangements that maximise the benefits of both water end-users and water investors.

This thesis seeks to gain a better understanding of investments on water assets (stocks, funds and indices). Specifically, there are three research objectives. First, it seeks to assess the profitability of investing in the water industry market. The first study entails:

- (i) a review of investment returns in water industry (Jin, Y., Li, B., Roca, E., & Wong, V. (2014). Investment returns in the water industry: a survey. *International Journal of Water*, 8(2), 183–199. doi: 10.1504/IJW.2014.060965);
- (ii) an assessment of the risk-adjusted returns on water stocks and their relationships with the whole market; and
- (iii) a test of the diversification benefits by including water stocks as an alternative asset (Jin, Y., Roca, E., Li, B., Wong, V., & Cheung, A. (2015). Sprinkle your investment portfolio with water! *International Journal of Water*, 9(1), 43–59. doi: 10.1504/IJW.2015.067445).

Then, it aims to understand risk factors affecting returns on water stocks. Two types of risks are investigated. The first one is liquidity risk. The second study of the thesis involves:

- (i) a review of asset-in-place risk in asset pricing;
- (ii) an analysis of the impact of asset liquidity risk on water companies' stock returns;
- (iii) understanding whether asset liquidity risk varies across firms and over time
(Jin, Y., Roca, E., Li, B., & Wong, V. (Under Revision). Water as an investment: Liquid yet illiquid! *Applied Economics Incorporating Applied Financial Economics*.).

The second type of risk is regulatory risk, which is believed to have substantial influence on the water industry. The third study of the thesis involves:

- (i) a review of the impact of regulatory changes on stocks' systematic risk;
- (ii) an assessment of the effect of regulatory changes on China's water industry as a whole;
- (iii) an exploration of regulatory effects on individual water companies traded on the Chinese stock markets (Jin, Y., Roca, E., Li, B., & Wong, V. (Under Review). Regulation and Systematic Risk in the Water Industry: Evidence in the Context of China, *Journal of Regulatory Economics*).

1.2.2. Research Significance and Contributions

The research questions described above are designed to address the complexities of the water sector. Despite the various innovative financing solutions encouraging private

investors' participation in the water industry, the expected surge in the flows of private investment did not materialise (OECD, 2009). On the contrary, a number of experiences involving the private sector since the 1990s have fallen short of expectations for all parties involved, and led in some cases to highly politicised debates and international arbitration. The poor understanding of the profits and risks involved in private sector participation in such a complex sector has contributed to these difficulties (OECD, 2009).

The complexities of the water sector can be broken down into two types of risks. These risk factors make private sector participation very complicated and thus deterring commercial financing. According to OECD (2009), water projects are usually capital intensive, involving high and irreversible investments, long payback periods and low rates of return. This profile is associated with a high level of risk considering that the real assets of a water company tend to be very illiquid. Moreover, other than the commercial risks, water companies are often under the risk of political interference, which brings more uncertainty about their profitability.

So far the literature has had little knowledge about the risk and returns of water investments. No previous studies have attempted to explain how investors measure real asset liquidity risk and value risky assets. The gaps in the literature have obstructed the progress of privatisation of water sector. Furthermore, as the private participation in water sector is generally part of a broader set of policy reforms in many countries (Sirtaine, Pinglo, Guasch,

& Foster, 2005), the paucity of knowledge related to water investments also hinders reforms that are expected to improve sector performance, to increase levels of service coverage and to attract private sector financing for long-delayed investments in various water projects.

This thesis aims to extend the literature by examining the three research questions. It is believed that answering these questions shall shed light on water sector investments in three ways. First, by modelling the prices of water stocks, it explains the risks and related premiums in the investments in water companies. Both institutional investors and retail investors should gain some clarity in terms of the profitability of including water products as an alternative asset in their investment portfolios. Second, government institutions may be particularly interested in this research. It describes the potential risks concerned by investors and the following premiums they ask for compensation. Based on this knowledge, policy makers can determine if reasonable profits can be generated by water investors and form/adjust policies accordingly. For instance, an appropriate allocation of risks and responsibilities shall be underlined to make the best of privatisation of water sector. Finally, end-users would indirectly benefit from the research through lowered water prices and better services resulting from appropriate policies and alleviated water scarcity.

OCED (2009) points out that, to some extent, private sector participation brings to light the tensions generated from the development of water infrastructure. These tensions would usually remain hidden when infrastructure is kept in the public sector. In that sense,

research on the risk and returns on water investments will not only benefit private participators, but provide a set of important tools and practices to facilitate the development of water projects in the public sector.

In summary, this thesis clearly establishes the magnitude and significance of the water industry. It highlights the paucity in the research of the risk-return profile of water investments and illustrates the theoretical, practical, social and political needs for empirical work. The thesis expands the asset pricing theory and builds a link between the theory and liquidity ratio (i.e., a fundamental accounting variable which measures a firm's exposure to risks resulting from having a large proportion of illiquid assets). It provides evidence supporting the notion of a time-varying beta that is influence by regulatory risk. Moreover, the thesis has important implications for the management of water resources. It draws attention to the challenges associated with investigations in this highly fragmented yet heavily politicised industry and serves as a stepping stone for future research.

1.2.3. Theoretical Foundation

The thesis is based on the modern portfolio theory and the asset pricing theory. Building on the existing theories, there has been an increasing interest in identifying factors that accurately predict returns. The thesis commences by examining the performance of water assets in a portfolio context. Guided by the modern portfolio theory, the first study of the

thesis considers the water asset class as an alternative investment vehicle and assesses whether including water assets in a traditional investment portfolio can bring higher returns and greater diversification benefits. Studies 2 and 3 of the thesis utilise the asset pricing models (e.g., the CAPM and the Fama and French three-factor model) which are developed on the basis of the modern portfolio theory. Specifically, the second study investigates the risk characteristics of the water industry as an extension of the Fama and French three-factor model, while the third study considers the time-varying feature of betas and estimates the regulatory risk of water businesses by analysing the effects of regulatory announcements on their betas.

1.2.4. *Research Methodology*

In view of the research objectives, the thesis entails three studies. The first study of this thesis examines the profitability and diversification effect of water investments. Markowitz mean-variance portfolios are constructed and so are optimal risky portfolios. For each constructed portfolio, its Value at Risk and the Conditional Value at Risk are estimated to measure the downside risk. The study uses Gibbons, Ross and Shanken's (1989) *F*-tests to compare the performance of portfolios with and without water assets. The World Water Index, maintained by the Dow Jones Index and the Sustainable Asset Management Group, is employed to reflect economic activity in the water sector. The stock portfolio is represented by the MSCI World Index, while the Barclays Global Aggregate Index is chosen to represent the global bond market performance. The data used for this study include daily returns on the

three representative indices of the stock, bond and water markets, respectively, for the period between 1st January, 2004 and 31st May, 2012.

The second study focuses on the asset-in-place liquidity risk of water companies. It uses the ratio of fixed asset to total asset as a measurement of asset liquidity. Using four step-wise regressions, it investigates the joint explanatory power of all variables and assesses the relationship between returns and asset liquidity, beta, size and book-to-market ratio. Panel data analysis is used because it accounts for both cross-sectional and time-series effects while controlling for unobserved factors affecting water industry's systematic risk. Specifically, four different approaches are used including simple pooled Ordinary Least Square regression, one-way (firm) fixed effects regression, two-way (firm and time) fixed effects regression and random-effects regression. The study sample consists of all of the 76 firms that comprise the five most representative global water indices – ISE Water Index, NASDAQ OMX Global Water Index, NASDAQ OMX US Water Index, S&P Global Water Index and the World Water Index. The selected water indices are composed of publicly traded companies that have been active in the global water industry. These companies have a balanced representation from different segments of the water industry such as utilities, infrastructure, water treatment and industrials. For this study, panel data for the 76 firms during the period of 1st July 2001 to 31st December 2012 are obtained from DataStream.

The third study aims to explore the impact of regulatory announcements on the systematic risk of water businesses using a two-step procedure. In the first step, it estimates the systematic risk of water companies based on the CAPM. Employing the Kalman Filter procedure, the betas are allowed to vary over time. In the second step, further tests for the impact of regulatory intervention risk on water companies are conducted by regressing betas on different types of regulation announcement events. Specifically, there are five types of regulatory announcements that are expected to cause increased competition within the industry, decreased competition within the industry, increased water prices, decreased water prices and increased quality of services. China's private water sector is selected to be the target of this study, owing to its giant size, rapid development, and regional and global influence. Moreover, the existence of water regulators at the central government level makes regulatory risk easy to assess. The study sample consists of 19 Chinese water companies that trade publicly on the Shanghai and Shenzhen Stock Exchanges. These companies provide direct water and sewage services to end-users, and these services constitute their main source of revenue. Panel data for the 19 firms covering the period from 1st January, 2002 to 31st December, 2013 are obtained from DataStream.

1.2.5. *Main Findings of the Thesis*

The first study of the thesis shows that the water asset class outperforms the traditional asset classes. It is found that the water sector has low correlations with the

traditional asset classes and has the capacity to yield diversification effects in portfolios. This suggests that the water sector can be used as an alternative investment asset class.

The second study of the thesis finds that asset illiquidity is positively associated with stock returns. Specifically, water firms with a larger proportion of illiquid assets-in-place are observed to have greater stock returns than those with a smaller proportion of illiquidity assets. This study supports the notion that the irreversibility or illiquidity of assets-in-place produces a distinct effect in explaining water stock returns.

The third study of the thesis demonstrates that although there is no evidence supporting an overall regulatory intervention risk for the water industry, certain types of regulatory announcements made by water authorities have significant impacts on the systematic risk of water industry. The results imply that how regulatory changes affect the systematic risk may be dependent on investors' interpretation of a larger political environment.

1.3. Structure of the Thesis

The organisation of this thesis is as follows. Chapter 1 contains an overview of the water industry, water-related investments, research significance and research design. It points out severe water shortage worldwide and the huge financing gaps which have contributed to the shortage of water. After discussing water privatisation – a solution to the current water problems, it describes the challenges (i.e., asset liquidity risk and regulatory risk) that are

associated with private water investments. Chapter 2 discusses the theoretical framework underpinning the present research. Chapter 3 includes a co-authored journal paper published in *the International Journal of Water*. It provides a background of the development of the water industry, reviews existing research on the performance of water investments and identifies the research challenges in this area. Chapter 4 investigates the profitability of water-related investments and their diversification in a portfolio context. This study is also published in *the International Journal of Water*. Chapter 5 investigates the effect of asset liquidity risk on the returns on water companies. This paper is submitted to *Applied Economics Incorporating Applied Financial Economics* and is currently under revision. Chapter 6 examines whether regulatory announcements relating to competition, pricing policy and quality of water services have an impact on the systematic risk of China's water businesses. This paper is submitted to *Journal of Regulatory Economics* for review. Finally, Chapter 7 concludes and outlines possible future research directions.

Chapter 2 Theoretical Framework

2.1. The Modern Portfolio Theory

The thesis adopts the modern portfolio theory and the asset pricing theory and investigates the profitability and characteristics of water assets. The modern portfolio theory is based on the trade-off between risk and return in a portfolio context. The theory claims that a properly diversified portfolio would provide maximum return for a given level of volatility, or minimum volatility for a given level of return (Markowitz, 1952, 1959). This theory is often credited to Markowitz (1952) who first showed that the variance of the rate of return is a meaningful measurement of portfolio risk, under the assumption of rational and risk adverse investors.

The concepts of risk and return are central to the modern portfolio theory. Investment analyses and decisions require the estimation of expected future returns, while the spread of distribution of expected returns around the overall expected mean is usually measured by the variance, which is a conventional risk measure. The higher is the expected risk, and the greater is the required return. When assets are combined in a portfolio, the expected return is a weighted average of the individual assets' expected returns. The portfolio risk is more complex to estimate than the return. It is dependent upon not only the weights of individual risks but the correlations between the assets. The association between returns on different assets is negatively related to the diversification benefits; the portfolio risk is at its maximum

when all asset components are perfectly positively correlated. In effect, investors holding a diversified portfolio with not perfectly correlated assets could eliminate the risks associated with the individual assets.

The modern portfolio theory does not only indicate the importance of diversifying investments to reduce the total risk of a portfolio, but shows how to efficiently do that. The process of diversification starts by identifying various asset classes to be considered and their proportions within a portfolio. Then, efficient frontier is constructed by changing the proportion of each asset in the portfolio. It describes the highest expected return on all feasible portfolios available with the same level of risk, or the lowest level of risk for a given level of return. The line is efficient because the portfolios on the frontier dominate all other attainable portfolios. Portfolios do not exist above the efficient frontier, and portfolios below the frontier exist but cannot offer more appealing alternatives to points along the frontier (Sandberg, 2005).

Having identified all the possible optimum points, it is the decision of investors to select among them, based on their risk-return trade-off preferences. The risk and return trade-off is determined by indifference curves representing different utility functions. The optimum portfolio for an investor is therefore the point on the efficient frontier, which is tangent to the highest indifference curve. In general, the literature suggests that the concept of portfolio diversification has solid theoretical and empirical foundations (Asness, 1996; Beirman, 1998).

Following the modern portfolio theory, the first study of the thesis considers the water asset class as an alternative investment vehicle and assesses whether including water assets in a traditional investment portfolio can bring higher returns and greater diversification benefits.

Markowitz (1952) uses the variance and/or standard deviation (mean-variance approach) to define volatility. However, the standard deviation is not a precise definition of risk (Artzner, Belbaen, Eber, & Heath, 1997, 1999), and investors' real concerns are about the downside risk, especially the probability of loss. This shortcoming of Markowitz's portfolio theory has motivated researchers to develop alternative portfolio selection frameworks. Several studies attempt to quantify extreme losses or tail-risks for risky assets and capital intensive investments. Fung and Hsieh (1999) find that optimal portfolio weightings under the mean-variance framework are inaccurate as they do not take into account the high probability of large negative returns (tail-risks). Emmer, Korn and Kluppelberg (2001) concentrate their investigation on the lowest 1st to 5th percentiles in measuring the Capital-at-Risk, which they define as the Value at Risk (VaR) when developing an optimal portfolio. Alexander and Baptista (2002) contend that the new approach of managing portfolio VaR is an improvement compared with the traditional mean-variance method.

However, the VaR model is not flawless. Acerbi and Tasche (2002) find that when there are discontinuities in the loss of distribution, the VaR may fail to yield a coherent

measure of risk. To overcome the shortfall of the VaR model, Uryasev (2000) and Rockafellar and Uryasev (2000) provide algorithms for the portfolio optimisation problem in a Conditional-Value-at-Risk (CVaR) framework. The CVaR portfolio selection framework does not experience the incoherent mathematical properties of the VaR and measures the expectation of losses greater than or equal to the VaR. Szergo (2002) claims that the CVaR can avoid disastrous results that may arise from employing VaR as a measure of risk in many situations. In general, both the VaR and CVaR frameworks further develop the portfolio theory and have been widely used by investors. Hence, the first study of the thesis adopts the VaR and CVaR frameworks and evaluates how water assets as an alternative investment class can affect a portfolio's risk and return.

2.2. The Asset Pricing Theory

Building on Markowitz's modern portfolio framework, Tobin (1958) finds that investors prefer to hold certain risk-free assets even when their returns are low. Subsequently, Lintner (1965), Mossin (1966) and Sharpe (1964), independently develop a model that combines the use of risk-free assets with efficient frontier. Such a model has come to be known as the Capital Asset Pricing Model (CAPM). The CAPM describes how investors determine expected returns, and thereby the prices of risky assets, based upon their volatility relative to the market as whole.

The CAPM implies a capital market where risk-averse investors would prefer to hold portfolios that are comprised of risk-free assets and a certain portfolio situated on the efficient frontier (Fabozzi, 1999). With a risk-free asset included, the efficient frontier is no longer the best that investors can achieve. The Capital Market Line, which has the risk-free rate as its intercept and is tangent to the efficient frontier, is now the highest boundary of the investment opportunity set. Investment returns are governed by a risk-free return and a risk premium that are based on the correlation between the asset's risk and the market's risk (Lintner, 1965).

The CAPM postulates that expected excess return to an asset must be a function of its riskiness. Every investment carries two distinct risks – the systematic and unsystematic risks. The unsystematic risk is unique to individual assets and can be diversified away in large portfolios. Comparatively, the systematic risk is the portion of an asset's variability that can be attributed to a common factor resulting from general domestic market and economic conditions. It represents risk that cannot be diversified away. Consequently, only the undiversified systematic risk needs to be rewarded. The systematic risk is often referred to as an asset's beta and helps measure a portfolio's return that an investor can expect for taking the risk.

Early work generally supports the CAPM; however, subsequent research evidence illustrates that the CAPM is inconsistent with numerous empirical asset pricing data. Several deviations from the CAPM – 'anomalies' have been found. The CAPM demonstrates little

power in explaining the returns on assets that have different features on size and book-to-market ratio. Therefore, skeptics of the CAPM posit that the model, by use of beta, does not accurately capture the risk faced by investors. This is because several of the underlying assumptions of the CAPM are overly simplified and do not capture the reality. Therefore, the asset pricing literature has developed alternative theories and puts forward several extensions of the basic CAPM. For example, some researchers add new risk factors to the asset pricing model as they believe that investment returns cannot be decided solely by the systematic risk; others question that the assumption of a stable beta and allow their betas to vary over time.

2.2.1. Multifactor Models

Due to the existence of various anomalies, the beta is believed to be an incomplete variable in the measuring of risk. In this context, the extensions of the CAPM and other asset pricing models are developed with the aim of capturing other characteristics of stocks besides their betas. Ross (1976) proposes the Arbitrage Pricing Theory (APT), which seeks to move the asset pricing analysis away from the mean-variance efficient portfolios that form the basis of the CAPM. While the CPAM is a model of financial market equilibrium, the APT starts with a less restrictive assumption that arbitrage opportunities should not be present in efficient markets, and the capital markets are not perfectly correlated. It assumes that there are various factors, which cause asset returns to systematically deviate from their expected values. In order to prevent arbitrage, an asset's expected return must be a linear function of its

sensitivity to these common factors (Brown & Reilly, 1997): $E(R) = R_f + \beta_1 \lambda_1 + \beta_2 \lambda_2 + \dots + \beta_n \lambda_n$.

The APT suggests that there are a number of sources of systematic risk, while there is only one source in the CAPM. Examples of such factors include inflation, GDP growth and interest rate. When the prices of assets do not reflect these risks, it is expected that investors would enter into arbitrage arrangements until the relevant prices are correlated with the risks. However, the theory does not specify the number of risk factors nor identify these factors.

In an effort to better identify factors that derive asset returns, Fama and French (1993) devise a three-factor pricing model, employing three factors, namely, size, book to market value of the equity and a market factor: $E(R_{it}) - R_{ft} = \beta_{im} [E(R_{mt} - R_{ft})] + \beta_{is} E(SMB_t) + \beta_{ih} E(HML_t)$, where R_{mt} is the return on the market portfolio of assets, SMB_t is the difference between the return on a portfolio of small stocks and that on a portfolio of big stocks, and HML_t is the difference between the return on a portfolio of high book to market value stocks and that on a portfolio of low book to market value stocks. Fama and French (1993) conclude that their three-factor model performs better than the CAPM in explaining asset returns. They argue that the previously documented positive relation between beta and average return is an artifact of the negative correlation between firm size and beta. When this correlation is accounted for, the relation between beta and return disappears. The Fama and French three-factor model has been widely accepted by the literature as a

particularly useful framework since its proposal. However, the authors point out that they cannot explain why or how the additional two factors (size and book to market ratio) affect prices (Fama & French, 2004). This leads to questions about the rationale behind the three factor model.

Notwithstanding, the literature on the multifactor models continues to grow by discovering and incorporating new risk factors into the Fama and French three-factor model. For example, after Jegadeesh and Titman (1993) reveal the momentum factor, Carhart (1997) create a four-factor model to investigate the persistence of the mutual fund performance. This model extends the Fama and French three-factor model by including a new term of momentum, which is the difference in returns between a portfolio of firms with the highest return in the prior 12 months and a portfolio of firms with the lowest return in the prior 12 months. Carhart (1997) claims that this model helps explain some of the short-term persistence effects in mutual fund returns. Similarly, Brennan and Subrahmanyam (1996) and Chordia, Subrahmanyam and Anshuman (2001) identify a risk factor related to the liquidity of trading stocks after controlling for the Fama-French three factors. Building on the existing work on asset pricing theory, there has been an increasing interest in identifying factors that accurately predict returns. The second study of the thesis aims to investigate the risk characteristics of the water industry as an extension of the Fama and French three-factor model.

2.2.2. *Time Varying Beta*

As stated above, some researchers seek to discover characteristics of stocks in addition to their betas, while others begin to challenge the beta stability assumption of the CAPM. The original CAPM proposed by Lintner (1965) and Mossin (1966) and Sharpe (1964) is a static or single-period model which ignores the multi-period nature of participation in the capital market. In the original formulation, the model assumes that asset returns are stationary so that their distributions have time-invariant moments. As such, it implies that an asset's beta does not change over time. However, the constancy of beta over time is a very restrictive and unrealistic assumption. It has long been recognised that the beta could not be stationary in practice, and the failure of accounting for time-variation in conditional moments may have led to the poor empirical performance of CAPM (Brooks, Faff, & Lee, 1992; Cooper & Currie, 1999).

Consequently, researchers begin to consider beta as a time variant in their studies in order to rectify the misspecification of the source of risk. The time-series approach suggests that the beta summarises several sources of risk, and therefore should be varying over time (Groenewold & Fraser, 1999; Morana & Sawkins, 2000). A number of different techniques such as Kalman Filter approach and the multivariate generalised autoregressive conditional heteroskedasticity model (Bollerslev, 1990) have emerged by which one may model and estimate time-dependent beta. However, there is no consensus as to which factors affect the beta. There has been literature specifying beta as a function of a set of variables such as firm

size, dividend price ratio, regulatory announcements, default premium, and yield of Treasury bills (Antoniou & Pescetto, 1997; Gonzalez-Rivera, 1997; Robinson & Taylor, 1998). The third study of the thesis is based on time-varying beta assumption. Specifically, it estimates the regulatory risk of water businesses by analysing the effects of regulatory announcements on their time-varying betas.

Chapter 3 Investment Returns in the Water Industry: A Survey¹

Although the water industry has become a growing topic in the past decade, research on the returns on water investment is scarce. This paper provides a background of the development of the water industry, reviews existing research on the performance of water investments, and identifies the research challenges in this area. In conclusion, there are various ways for private investors to participate in the water sector. Generally speaking, water stocks have outperformed the stock market (broad market portfolio); however, the returns on water investments vary substantially with the chosen assets. The lack of reliable market research data may be a result of the fragmentation of the industry. Research is urgently needed in this field, with a particular emphasis on the returns investors could gain from investing in water assets.

3.1. Introduction

The water industry plays a significant role in today's economies due to its huge capital demands and related public policy issues. Although there is a lack of agreements on the existing or the optimal level of investment in this industry, by all appearances resources devoted to it dwarf those in most other sectors (Berg & Marques, 2010). However, literature

¹ This chapter has been published as a paper with the following details: Jin, Y., Li, B., Roca, E., & Wong, V. (2014). Investment returns in the water industry: a survey. *International Journal of Water*, 8(2), 183–199. doi: 10.1504/IJW.2014.060965. Statement of Contribution as a co-author can be found in pages x-xv.

on the water industry is not consistent with the importance of the sector. Based on a comprehensive literature survey, Berg and Marques (2010) note that there are only a small number of quantitative studies related to the water industry published each year and few academic scholars are sustainedly engaged in this area. This observation is surprising given the importance of this industry to economy. Fortunately, attention from other analysts has been slowly growing in the past ten years.

Among the existing quantitative studies of the water industry, most research focuses on topics such as the impact of ownership arrangement, economies of scale and external effects of public goodness, which are policymaking issues rather than business or finance related questions. To date, only a small fraction of the papers have attempted to assess the comparative performance of water industry. The research gap perhaps reflects the challenge in creating a reliable data set for enterprises (Maxwell, 2011).

Berg and Marques (2010) conduct an exhaustive review of the empirical literature on water and sanitation services providers. They examine the number and pace of publication, when and where these studies have appeared, and the countries/regions investigated. In addition, they briefly summarise the methodologies and some issues addressed by the studies reviewed. Berg and Marques' review performs a literature census, providing us with a summary of the quantitative studies of the water industry. However, it lacks a deep

investigation of any specific topics of the water industry, such as financing approaches and performances of water companies.

In this context, our review aim to provide a background on water-related investments, to review the literature on the benefits of investing in water related businesses, and to put forward several unresolved issues in this field. We first present the development of the water market in Section 2, followed by a review of the forms of investment available to investors and the main indices used to track the market in Section 3. We then discuss the performance of water projects and water stocks, and its contributing factors in Section 4. Lastly, in Section 5 we raise issues surrounding the complex composition of the water industry, the position of water assets in an investment portfolio, the attractiveness of regulated markets versus deregulated markets, and the future of the water industry following the global financial crisis of 2008, before we conclude this paper in Section 6.

3.2. Background

The businesses involved in the storage, purification and delivery of water have been flourishing by an exploding global demand for high quality water in the past two decades. Investment interest in all facets of the water industry has been booming correspondingly. Meanwhile, it is worth noting that water investment itself has gone through drastic transformations during this period (OECD, 2009).

In the past, the water sector was seen as a public sector because water infrastructure around the world was largely owned and controlled by government agencies. Private capitals did not have many opportunities in this area. Since the early 1990s, more and more countries have started a process of deregulation in the water sector by transferring water companies from public institutions to private owners (Prasad, 2006). The worldwide reforms have attracted investors of all stripes rushing into this industry. In the beginning phase of the transformation, most participators were large corporate and strategic investors such as Suez, General Electric, and Siemens.

As the awareness of global water resource crisis increases in the 21st century, profit motivated investors begin to see the potential of water as a good investment vehicle. Followed by the privatisation of water companies, water utility stocks attract the interest of retail clients with their high dividends (Winter, 2009). Moreover, water industry is known as ‘recession-resistant’ due to the necessity of water, and is thus attractive to institution investors such as funds, and private equities. Strategic investors are also inclined to include water-related assets in their portfolio for its low risk and low correlation with other assets (Berlant, 2009). Nevertheless, despite the recent trend of water industry privatisation, most water infrastructures remain in the control of government agencies at this stage (Pinsent Masons, 2010).

3.3. Investment Forms

3.3.1. Municipal Bonds and Public Debts

As the concept of water investment becomes a hot theme, numerous new investment ideas begin to trickle in. Investors can loan money to water projects through municipal bond issues or other forms of public debt instruments (Maxwell, 2007). These vehicles are viewed as highly secure because investors loan money out at a fixed interest rate and have a very small chance of losing the principals. On the other hand, the long lending period and low return make such investments unattractive to more aggressive investors and most retail investors. Hence, these instruments only represent a fraction of water investments.

3.3.2. Water Projects

Another type of water investment is through specific water projects. In this situation, private capitals can choose to fund the construction of water projects which may or may not be owned by public institutions. In fact, governments have designed various financial structures with the goal of attracting and employing private resources for the development of water infrastructure. Under these arrangements, private entities contribute expertise and capitals to build and start operation of what will ultimately be a municipal facility (Prasad, 2006). In other words, private investors are allowed to invest money and gain a competitive rate of return on their investments before transferring ownership and/or operation of the facility back to a public agency. However, such investments do not usually present many liquidity options to investors, and the process is not always as transparent as investors might

wish it to be (Maxwell, 2007). Moreover, this investment vehicle is often not accessible to retail investors.

With the development of water markets, investing in stocks of individual water-related companies becomes a common way to play the global water boom (Twibell, 2006). Different from investments on water projects, water stocks are accessible to both retail and institutional investors. According to Winter (2009), water stocks usually have low risks but high dividends, and dividends are increasing each year. Other than superior returns on their investments, investors typically prefer to have the freedom of exiting the investments at their convenience. Compared with water bonds and water projects, the high liquidity gained from buying/selling stocks of publicly traded companies makes water stocks even more attractive.

While investing in the water industry may seem appealing, choosing stocks among numerous water companies is challenging, especially when considering the extensiveness of this industry. Water industry is a synthesis of quite different niche businesses; it is comprised of various types of companies (e.g., new technology developers, established product manufacturers and integrators, specialty chemical producers) (Maxwell, 2005). Furthermore, this industry is known for its fragmentation – there are a large number of relatively small companies competing against one another in nearly all segments, but no one single company seems particularly attractive to investors. In addition, most large- and mid-cap companies that are labelled as water companies often only have a fraction of revenues generated from water-

related businesses (Kearney, 2008). Hence, a few companies cannot cover or represent the entire water industry. Therefore, it is not feasible for investors, especially small investors, to capture the movement of the whole water market by investing in the stocks of water companies.

In this context, water exchange traded index funds (ETFs) were developed as an alternative investment approach. ETFs are baskets of water-related shares aiming at replicating the performance of water market (Rompotis, 2009). They offer investors the flexibility of buying or selling the entire water market with one single transaction. For example, the American Stock Exchange introduced the Palisades Water Index (ZWI) in 2003 and started to publish this index on a regular basis from 2005. Following the publication of the ZWI, two ETF funds – Power Shares Water Resources and Power Shares Global Water – were introduced to investors to assist them in keeping track of companies included in the ZWI (Keenan, 2008). Shortly after, other ETFs were made available to investors, such as Claymore S&P Global Water which is based on the S&P Global Water Index, and First Trust ISE Water which is based on the ISE Water Index (Atkinson, 2009).

3.4. The Performance of Investing in the Water Industry

3.4.1. *Background*

According to Guerrini, Romano and Campedelli (2010), research on the performance of the water industry started in the 1970s. These works adopt different research methods to

measure performance: models formed by key performance indicators; and models with an overall performance indicator that synthesises the trend of a group of measures (Klase, 1995; Marques & Monteiro, 2001; Shaoul, 1997). Most studies focus on the management and efficiency of water companies, while returns from the water sector were underfollowed. It is reasonable to conclude that the existing research contributes to the regulation and policy decision of the water industry, but provides limited information on the profitability of water investments.

Considering that the water industry has always been diffuse and fragmented, the paucity of reliable market research data may not come as a surprise. The following sections aim to review the existing literature on the profitability of water industry based on the forms of investment vehicles.

3.4.2. *The Performance of the Water Industry*

Usually, water investment (e.g., investment on water projects) is considered as a conservative choice. This is partly due to the nature of the industry. Water utilities, as infrastructure investments, often enjoy steady demand and a relatively predictable future. Investors tend to believe that investments on water businesses such as water supply or sewage treatment will offer them low but reliable returns (Association for Sustainable & Responsible Investment in Asia (ASrIA), 2007).

Internal Rate of Return (IRR) is often used in the analysis of profitability of water projects. Lawlor, McCarthy and Scoot (2007) apply a cost-benefit analysis to 51 water projects in Ireland. Their sample consists of water supply projects, wastewater projects and water conservation projects. Lawlor et al. (2007) find that in general, investments on these projects generate positive IRRs, but returns on the three types of projects are distinct. Specifically, projects related to wastewater have the lowest returns, with an average rate of return of 0.5%, and water conservation projects generate IRRs around 21.7%. However water supply projects' performance is mediocre, with an average IRR of 9.8% (Exhibit 1, Panel A). However, as the authors point out, the distinctness in IRRs do not only lie between different types of projects, but occur within the same type of projects.

While the above study estimates different water projects' returns in one country, Sirtaine, Pinglo, Guasch and Foster's (2005) investigation covers 10 water concession projects in five Latin American countries. They study the project returns that measure the overall attractiveness of the projects as business entities, as well as the shareholders' returns which are effectively from the distribution of dividends and other sources of funds generated by the projects. Unfortunately, both kinds of returns seem unattractive. The averaged project return (returns on capital employed) is only 4.3%, while the weighted average cost of capital (WACC) is approximately 10%. The gap between shareholders' return (dividends) and cost appears to be even larger where their return is negative and the cost of equity is higher than the WACC (Table 3.1, Panel A). Sirtaine et al. (2005) estimate that, through deep sensitive

analyses, concession projects themselves may be able to generate long term returns in line with the WACC, after adjustments of management fees and growth rates; while the shareholders could hardly recover their costs even by adopting a reasonably high dividend payout ratio. This may be due to the low average profitability of these concession projects and the low dividend distribution policies. In other words, without subsidies from governments, the water concession projects in the five Latin American countries would not provide investors with an adequate long-term return relative to the risk taken.

Compared to the limited research on returns on water projects, the interest on stocks of water companies and the related derivative instruments has been growing, possibly due to the encouraging results from the outstanding performance of water stocks (Antoniou, Barr & Priestley, 2001; Dickinson, 2010; Geman & Kanyinda, 2007). This argument is well supported by various evidence suggesting that most water indices – created by financial institutions as investment vehicles or by academic researchers for research purposes – have stronger performance than other indices (Ben-Amin, 2010). For example, Schwab (2004, cited in Howe (2006)) argued that their index of water stocks soundly outperforms many benchmark indices such as the Dow Jones Industrial Average, the S&P500 and NASDAQ since January 2001. The water industry stocks rose 24% in 2004, ahead of the S&P500 increase of 11%. Although the water indices have been influenced by the common business and political conditions such as the post- September 11, 2001 slump (Howe, 2006), the trend of the water indices was clearly upward prior to 2008.

The financial crisis of 2008 greatly affected the water industry and put an end to its continuous growth. During the crisis, the correlations of the water sector with other sectors increased, which resulted in lowered diversification effects (Dickinson, 2010). Therefore, investors became more cautious of the thematic concept of water investment, and preferred indices of familiarity. Consequently, the water funds saw a large quantity of outflows during the crisis. For instance, the assets under the management of Pictet Water Fund dropped from its high at €4.7 billion in July 2007 to €2.3 billion in 2010 (Dickinson, 2010). However, it is worth noting that most water companies did not experience significant declines in the market downturn, and the water stocks continued to trade at healthy multiples (Winter, 2009). Water funds and ETFs maintained better performances compared to the market. According to Bloomberg (2010), the five-year annualised return for the S&P Global Water Index in 2010 was 5%, while that for the S&P 500 and the DJ UBS Commodity Index was -1.5% and -2.8%, respectively.

Generally speaking, research on the water industry has substantially reduced following the financial crisis of 2008. In particular, there is a blank in the research of the performance of water assets. Consequently, the only available source is the statistics from financial institutions. Table 3.1, Panel B presents a summary of returns and risks of water-related derivatives (i.e., funds, indices and structured products) in the past five years.

Table 3.1 Performances of water investments

Panel A: Returns on the Water Projects									
Lawlor, McCarthy & Scott (2007)	Project Type	Water Supply Projects			Waste Water Projects			Water Conservation Projects	Water Projects as A Whole
		Water treatment	Water distribution	Water treatment and distribution	Waste water treatment	Sewerage	Sewerage & wastewater treatment		
	IRR	22.40%	16.20%	5.20%	2.80%	-0.80%	-3.50%	21.70%	6.60%
	Note: The projects were initiated during the period 1994 – 1999								
Sirtaine, Pinglo, Guasch & Foster (2005)			Project		Shareholder				
		IRR	WACC	IRR	Cost of Equity				
	Without adjustment	5%-6%	10%-11%	-45%	13%	Note: sample period from 1993 to 1999			
	Adjusted for growth rate	22%	10%-11%	-40%	13%				
Adjusted for growth rate and dividend payout	N/A	N/A	8%	13%					
Panel B: Returns and Risks of Water Products									
Water Funds & Structured Products	Product	Returns			Sharpe Ratios			Published	
		5 Years	3 Years	5 Years	5 Years	3 Years	5 Years	Date	
	First Trust ISE Water Index Fund	N/A	10.75%	N/A	N/A	N/A	N/A	12/2011	
	Pictet Water	5.31%	71.5%	N/A	N/A	1.46	N/A	03/2012	
	PowerShares Global Water	N/A	14.82%	N/A	N/A	0.73	N/A	01/2012	
	PowerShares Water Resources	-0.05%	13.75%	0.09	0.66	N/A	N/A	01/2012	
	Sarasin Sustainable Water Fund	N/A	59.20%	N/A	1.07	N/A	N/A	02/2012	
	SAM Sustainable Water Fund	-12.69%	57.85%	N/A	N/A	N/A	N/A	03/2012	
	Swisscanto Equity Fund Water Invest	N/A	16.9%	N/A	N/A	N/A	N/A	05/2012	
	Tareno Waterfund	-3.25%	50.62%	N/A	N/A	N/A	N/A	05/2012	
Water Indices	ISE Water Index	3.25%	11.51%	N/A	0.54	N/A	12/2011		
	S-Network Global Water Index	-19.38%	35.69%	-0.235	0.639	N/A	03/2012		
MSCI World	MSCI World	-13.35%	62.94%	-0.143	0.962	N/A	03/2012		
Note: The statistics are adopted from the fact sheets of the related water products or Bloomberg.									

Panel C: Descriptive Statistics on Water Stocks

Antoniou, Barr & Priestley (2001) – Sample period from January 1990 to September 1995

Company	AW	WW	NB	STW	SWW	SW	TW	NWW	WXW	YW	Water portfolio	FTA
Mean return (Monthly)	0.65%	0.76%	1.31%	0.92%	0.62%	0.93%	0.61%	0.96%	0.89%	0.78%	0.84%	0.27%
Standard Deviation	6.69%	6.14%	6.80%	6.48%	6.33%	6.76%	6.18%	6.25%	6.81%	7.15%	6.08%	4.58%

Buckland & Fraser (2001) – Sample period from 1989 to July 1999

Company	AW	HW	UW	NOW	SW	STW	TW	WW	KW	PW	FTA
Mean return (Daily)	0.4%	0.04%	0.04%	0.09%	0.08%	0.05%	0.05%	0.06%	0.05%	0.06%	0.03%
Standard Deviation	1.41%	1.41%	1.41%	1.41%	1.73%	1.41%	1.41%	1.41%	1.41%	1.41%	0.77%

Roca & Tularam (2012)

Region	1 July 1993 to 10 September 2001				17 September 2001 to 31 October 2007			
	Asia		Europe		US		Asia	
Mean Return (Daily)	-0.045%	-0.018%	-0.018%	-0.043%	-0.043%	-0.103%	-0.062%	-0.073%
Standard Deviation	3.428%	1.180%	1.180%	1.457%	1.457%	1.756%	1.017%	1.283%

In spite of excessive returns from the water stocks, the profitability of water investment may be debatable. Dow Theory Forecasts (2009) believe that this industry has little investment potential and is not very safe to invest. They argue that shares of water business substantially underperformed those of other utilities. As a traditional utility, water industry may not be the one experiencing exploding growth (in the past or in near future), and is more likely to undergo an unspectacular but consistent growth (Maxwell, 2005). Though a few subsectors of the water business grow at an annual rate of 15-20%, the growth of the overall industry may not be so prominent. A more realistic estimate is that it will be a little in excess of the gross national product or population growth rates (Maxwell, 2005).

Nonetheless, an absolute measure of return alone is not meaningful because it neglects the risk an investor has to bear. All else being equal, a risky investment is less desirable than a safer one; the higher the risk of an investment, the higher the return has it to generate in order to attract investors. Therefore, it is essential to consider both risk and returns when evaluating water investments.

Roca and Tularam (2012) investigate the prices of water stocks on the U.S., Europe and Asia markets, through studying the performance of the DS Water Index which represents 75–80% of the market capitalisation. The sample period is from July 1, 1993 to October 31, 2007. Their results indicate that the mean daily returns on the DS Water Index are negative,

ranging from -0.103% to -0.018% and the Standard Deviations (SD) are mostly between 1% and 1.5% (Table 3.1, Panel C).

Researchers have been investigating the factors/risks affecting the water industry (i.e., the source of the returns) and more importantly, examining whether there are abnormal returns from water investments that cannot be explained by the undertaking risk. As a pioneer in the wave of utility privatisation, the U.K.'s water industry has generated more research and investment interest than that in other countries. Antoniou, Barr and Priestley (2000) analyse the returns on water stocks from financial markets, but fail to find any evidence of abnormal return. They use a conditional asset pricing model to account for expected returns on ten water companies in the U.K. (Table 3.1, Panel C). They first reveal that water companies experience higher average rates of return than the market as a whole: the average monthly returns of the 10 selected water companies range from 0.62% to 1.31% during the period of January 1990 to July 1995. Additionally, they construct an equally weighted water portfolio which has a monthly return of 0.84%. The performance is much better than the market portfolio proxy – the Financial Times Actuaries (FTA) All Share stock index which has a monthly return of 0.27%. Correspondingly, the SD of water portfolio is slightly higher than that of the market. In a deeper analysis, Antoniou et al. (2000) apply the CAPM model and find that the water portfolio has a statistically significant positive alpha. This confirms the existence of abnormal returns in water sector. However, by adopting a general model that allows for time variation in investors' perceptions of risk, Antoniou et al. (2000) argue that

the observed high stock returns are better explained by the time-varying risk premium, and the abnormal returns are much smaller than anticipated. That is, the observed high returns on stocks of water companies are rewards for taking extra risks rather than abnormal returns.

The riskiness of water investments has been addressed in many research documents, however only a few of them consider risk as a source of returns or use it to explain returns. Evidence suggests that water utility's betas are not constant, but are a function of time; in addition, their volatility is also non-constant, displaying a tendency to cluster in time (Antoniou et al., 2000; Buckland & Fraser, 2001). Researchers attempt to associate the variation in betas with various regulatory factors; among which, the political and regulatory risk was discussed most often owing to the essentialness of water and water industry. For example, using the Kalman Filter procedure, Buckland and Fraser (2001) explore time-varying risk parameters in the British water industry for a sample period of ten years (Table 3.1, Panel C). The study compares 10 selected regional water companies in England and Wales (mirroring the water sector) and the FTA All Share stock index (representing the whole British market). As expected, the water stocks (with daily returns varying from 0.04% to 0.08%) outperform the market (with a daily return of 0.03%), but bear more risks. In the subsequent analyses, the authors estimate the time-variation in systematic risk and find evidence of political shocks. It appears that a few political and regulatory events have a great initial impact on the stocks' performance, and the influence can persist over time by affecting the long-term trend of betas. Nevertheless, in other times, betas are not so sensitive to

political risks. After nearly ten years of privatisation, systematic risk of the British water industry has stabilised into a pattern with a significant, but small cyclical component related to the political events.

Other than political factors, various defined and undefined elements also have an effect on the performances of water companies. For example, company size, diversification and ownership model are believed to be effective determinants (Shaoul, 1997). A considerable number of studies report the presence of economies of scale in water utilities; there is a positive relationship between size and efficiency in water business (Bhattacharyya et al., 1994; Kim & Lee, 1998). However, further studies also point out that this principle may only apply to small and medium utilities; while for big firms, the growth sometime causes diseconomies (Fraquelli & Giandrone, 2003; Torres & Pal, 2006; Tynan & Kingdon, 2005). The existence of economies of scope might be a good explanation of this tendency. Several researchers claim that the efficiency of water companies can be greatly improved through investment diversification and/or vertical integration strategy within the value chain of water industry (Fraquelli & Giandrone, 2003; Stone & Webster, 2004).

Contrary to the expectation, the majority of studies examining the relevance of ownership on performance of water utilities indicate that ownership structure does not necessarily have an impact on performance (Renzetti & Dupont, 2003) and private ownership may not improve efficiency (Guerrini, Romano, & Campedelli, 2010). Unfortunately, rather

than focusing on returns from financial markets, quantitative studies assessing performance and efficiency of water companies predominantly concentrate on the accounting ratios of water utilities. Financial analysis and a range of cost functions have been used for this purpose, which provide limited information on the benefits of investing in water assets. Few researches attempts to analyse the riskiness of water investments or further to price water assets. In order to understand the profitability of water industry, research from the perspective of investors is urgently required.

Table 3.2 presents a summary of the evidence documented in recent studies on the performance of the water industry.

Table 3.2 Recent studies on the performance of water industry and water assets

Study	Sample, Period and Methodology	Summary of Finding and Conclusions
Antonioni, Barr & Priestley (2001)	The study analyses 10 British water companies using a conditional asset pricing model to explain expected returns. The model allows changes in risk characteristics not captured by the traditional approach. Sample period ranges from January, 1990 to September, 1995.	Traditional static asset pricing models suggest that water utilities have abnormal returns. However, the study finds that the abnormal returns is much smaller than first thought, being present in only very few companies. The existence of abnormal returns depends crucially on the assumptions made with regard to their measurement.
Buckland & Fraser (2001)	This paper explores the scale and behaviour of abnormal returns observed in the equity of 10 water companies in the U.K. from 1989 to July, 1999. It employs the CAPM and techniques of the Kalman Filter to generate estimates of time variation in both systematic risk and abnormal returns coefficients.	It concludes, first, that there is substantial time variation to both risk and abnormal returns; and second, there is evidence of political and regulatory impacts upon both risk and returns. Significant excess returns were generated in the early history of the privatised water industry.
Geman & Kanyinda (2007)	The study reviews the performance of several water assets, and discusses the possibility of investing water resource as a commodity.	The study argues that the water indices outperformed the market. There are two types of water investments, through buying water industry shares and taking direct positions in futures contracts or structured notes of water as a commodity. The latter is not available worldwide.
Guerrini, Romano, & Campedelli (2010)	The paper reviews the annual financial statements of 80 Italian water utility companies between 2004 and 2008. It collects data on water tariffs, volumes supplied and population served. Finally, it discusses the significant differences among clusters, using parametric statistic methods.	Ownership structure, size, diversification and geographical location affects the performance of water utility companies, though with different degrees of significance.
Howe (2006)	The study examines the performance of a water index developed the author from 1999 to 2004. It uses statistical event analysis to scrutinise, in greater detail, the stock price reactions of some prominent rival firms. The purpose is to determine whether or not large highly publicised contract failures have negatively affected the market value of water firm.	The financial damage inflicted on the water industry by some large water business is minimal. It suggests that in this industry, firms build an expectation of failure events into their planning and risk analysis. The businesses thus appear to be financially resilient in the face of major setbacks.
Lawlor, McCarthy, & Scott (2007)	The paper summarises the results of ex post cost benefit analysis of over 50 projects in 14 cohesion-funded schemes in Ireland, falling into three broad categories: water supply, wastewater treatment and water conservation. These projects were initiated during the	The study generates mixed findings. The benefits of water supply and conservation investments are mostly internal, and are generally proven to be worthwhile. Wastewater investments are shown to be not profitable. The authors argue that the environmental data is needed for a full analysis of wastewater projects. (water supply investment: averaged IRRs varied from

	period of 1994-1996.	5.2% to 22.4%; wastewater investment: averaged IRRs varied from -3.5% to 2.8%; water conservation investment: averaged IRR was 21.7%).
Maxwell (2005)	This paper explores the size and boundary of water sector as well as its niche business.	It displays the diversity of water industry, and claims that the name of 'water industry' is in reality a confusing array of fundamentally quite different niche business.
Roca & Tularam (2012)	The study investigates the extent and manner of interdependence among the U.S., European and Asian water sector of the equity markets based on VAR, Granger causality and impulse response analyses. Sample period 1 is from July 1, 1993 to September 10, 2001. Sample period 2 is from September 17, 2001 to October 31, 2007.	The returns of Asia, European and the U.S. water sector were negative in both time periods. It is found that the world water stock market prices are significantly interdependent and each market responds to shocks from each other quickly and completes its response within three days.
Sirtaine, Pinglo, Guasch, & Foster (2005)	The study of water project is based on a sample of 10 concessions in five Latin American countries from 1993 to 2001. IRRs and returns on equities were used to measure the effective return. CAPM was used to formalise the hurdle rate.	The analysis shows that water concessions are not capable of generating adequate returns in the long term, hence are not potentially interesting business proposals.

3.5. Challenges in the Research on Water Investments

The water industry is very large and dynamic. It consists of a number of very large companies, and a far more dramatic grouping of mid-sized and smaller companies (Berlant, 2007). Different players actively participate in the market, for example, established service providers, product manufactures, and new technology developers. Maxwell (2005) claims that the so-called ‘water industry’ is in reality a confusing array of fundamentally different niche businesses – businesses that cannot be classified under any one single heading. The variety makes water assets suitable for different types of investors, because they fulfil various investment needs (Dickinson, 2010). As an infrastructure industry, the water supply businesses tend to exhibit low volatility compared to other assets, which gives investors a low systematic risk (beta); meanwhile, the riskier stocks of technology developers in the water industry are more likely to offer investors an abnormal return (alpha) (Dickinson, 2010).

The disadvantages of this diversity are apparent. Each niche sectors in the water industry has its own growth, profitability and strategic characteristics. Moreover, because of the excessive fragmentation, the industry has been undergoing a considerable amount of consolidation with a great deal of merger and acquisition activities (Berlant, 2007). Considering the difficulty of defining the industry and drawing boundaries around the niche sectors, estimating its market size and other

characteristics is likewise going to be difficult (Maxwell, 2005). This leads to an absence of good, reliable market research data and intelligence on the water industry (Maxwell, 2011). Although detailed studies have been conducted in a few specific fields of the water industry, more thorough and methodologically stringent overarching studies of the entire industry are required.

The complex water markets and a lack of reliable data make water investments tricky assets to fit into a portfolio (Dickinson, 2010). There are different ideas about its position in an investment portfolio: some see it as a commodity (e.g., Geman & Kanyinda, 2007), some think the utility might replace bond to some extent (e.g., Boyer & Ciccone, 2009), and others take it as an equity investment. Potential investors may be both surprised and frustrated by this situation, which might, in turn, limit the funds flowing into the industry, leaving water remaining a niche investment.

Water investment is a global trend. However, capitals in the water market are mostly pooled in developed countries (e.g., the U.K.). This is partly because these water markets are deregulated, providing players with a better access to the markets. Compared to regulated markets with limited volatility, deregulated markets are much easier for investors to develop derivative strategies (Dickinson, 2010). On the contrary, investments in emerging markets are unstable. Most transnational corporations see inadequate rates of return from those markets, of which many

choose to withdrawal business (Robbins, 2003). During the financial crisis of 2008, the deregulated water markets were believed to be more attractive, whereas some evidence recommends emerging markets as good opportunities, for the latter have reasonable risks but much higher returns (ASRIA, 2007; Tremolet, Cardone, Silva & Fonseca, 2007). In a closer look at the water stock markets, Roca and Tularam (2012) find that the world water markets are significantly interdependent and each market responds to shocks from each other as soon as within three days. The mixed results may be related to the methodological issues, for example, the varying water markets chosen as study subjects, rapid policy changes in developing countries, and diverging definitions of a successful investment.

It is noted that the research interest in water investments did not immediately recover following the financial crisis of 2008. Little information is available with regards to the post-2008 situation in either deregulated or regulated markets. It is yet unknown whether water investments are rapidly growing or to be recovered from the turmoil (Dickinson, 2010). Future studies need to ascertain the status of the water industry in the post financial crisis time.

3.6. Conclusions

The water industry is very large and dynamic. As the public sector has growing difficulty in meeting the needs of more quality water, water privatisation

becomes a popular solution, especially in developed countries. Private investors enter the water markets through investing in, for example, water projects and related bonds, stocks and other derivatives. Research typically focuses on policymaking issues (e.g., impact of ownership arrangement, economies of scale and external effects of public goodness). Research investigating the financial gains of private water investment from the stock market is scarce. Among the few studies that examine the profitability of water investment, it is found that water assets generally outperform the stock market, before and during the financial crisis of 2008 (Dickinson, 2010; Geman & Kanyinda, 2007; Schwab, 2004). However, the returns on water assets varied substantially between different types of water investment, as well as within the same category of investment. It is predicted that water industry is likely to undergo an unspectacular but consistent growth (Maxwell, 2005), and is positively related to the scale and scope of business (Fraquelli & Giandrone, 2003; Stone & Webster, 2004; Torres & Pal, 2006; Tynan & Kingdon, 2005). Political factors are postulated to have a great impact on the systematic risks of the water industry, and the political risks, to some extent, explain the high returns on water investments (Antoniou et al., 2000; Buckland & Fraser, 2001).

Despite the increasing interest in water investment, research is impeded by a lack of good, reliable market research data and intelligence on the water industry (Maxwell, 2011), which results from the challenges in defining the industry,

drawing boundaries around the niche sectors, and estimating the market size and other characteristics (Maxwell, 2005). Researchers have not yet reached an agreement on the position of water assets in an investment portfolio or the relative profitability in investing in regulated markets (ASrIA, 2007; Robbins, 2003). Future research should focus on the performance of water stocks and their derivatives, particularly that following the financial crisis of 2008.

Chapter 4 Sprinkle Your Investment Portfolio with Water!²

Traditional portfolios mostly only include equities and bonds; however, it was found that such a combination lacks sufficient diversification and often has a high volatility (Bender et al., 2010). The comparatively poor performance of traditional investment asset classes in recent years urged investors to search for greater returns through investing in alternative asset classes (Campbell, 2008). The most commonly used alternative investments include commodity, hedge fund, private equity and real estate. Unfortunately, such allocation of investments produced limited diversification effects as performances of many alternative asset classes are substantially influenced by the traditional stock and bond markets (Anson, 2008; Asness, Krau, & Liew 2001). Therefore, investors have never stopped looking for investment assets with better diversification benefits. Among the sectors, the water industry has been achieving strong and steady growth (Doerr, 2008). It profits from the growth of the world economy, and dynamics such as urbanisation and water shortage have also caused its prosperity. Investors generally believe that water assets can provide them with desirable risk-return trade-offs, which appears to be a driving force for private water investments. As a result, the increase of interest in the water sector in recent years should not come as a surprise.

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However, empirical evidence is lacking in supporting the intuition. According to Berg and Marques (2010) and Jin et al. (2014), there are only a small number of quantitative studies relating to the water industry published each year and few academic scholars are sustainedly engaged in this area. This observation is surprising given the importance of this industry to economy. The present study seeks to fill in the research gap by investigating the profitability and diversification effect of water investments.

4.1. Introduction

Water industry is one of the largest industries in the world. Water experts estimate the size of the global water industry today to be between USD 425 billion and USD 700 billion per year, while the numbers are poised for considerable growth (Geman & Kanynda, 2007). Unsurprisingly, the water industry has quickly become a hot space in the past two decades when many countries begin to privatise their water sector.

The increasing interest in water investment encourages investors' participation in the water sector. However, considering the magnitude of the water industry, it may not be optimal to invest in individual stocks or projects. In this context, water indices have been introduced to meet the needs of investors who are interested in this market. These indices are designed to assist investors in capturing

movements of the water market. Water funds were also created for investors looking for opportunities in this market. Presently, there are at least nine funds investing in the water industry partially or wholly in the forms of exchange traded funds (ETFs), open-ended conventional funds and investment trusts (Ben-Ami, 2010). These water indices and water funds reflecting risks and returns on the entire water industry market are likely to provide diversification of financial capitals for investors.

Interestingly, research on the profitability of water investment is generally lacking, and investors are ill-informed about the performance of water industry. Although in the past five years the possibility of including water funds in investment portfolios as alternative assets has generated some interest amongst institutional investors, it has not caught the eyes of academic researchers. Therefore, it will be of interest to understand through methodologically stringent studies the potential of using water indices as an alternative investment in addition to traditional investments, that is, the likelihood of gaining additional profits by adding water indices into investors' existing portfolios.

Our study will extend the literature by examining the questions described above. The World Water Index (WOWAX), which is designed to reflect major movements of the water market, will be used to represent the water industry market for the purpose of this study. Specifically, the study will involve consideration of

three perspectives: 1) risk-adjusted returns on the water index, 2) the relationships between the index of the water industry market and those of the stock and bond markets, and 3) comparisons of performances of a traditional portfolio and portfolios that include a water index as an alternative asset.

The remainder of this article is organised as follows. Section 4.2 reviews the important work completed in the field of water investment; Section 4.3 elucidates the development of the hypotheses, followed by Section 4.4 which discusses the research design; results will be analysed and reasoned in Section 4.5. A summary and conclusions will be discussed in Section 4.6, including the implications and limitations of the research and directions for future research.

4.2. Literature Review

The comparatively poor performance of traditional investment asset classes (such as stocks and bonds) in recent years urged investors to search for greater returns through investing in alternative asset classes (Campbell, 2008). Early research work on alternative investments study a small number of asset classes including private equity, real estate and hedge fund. In the last decade, researchers and investors have expanded their selection to include new classes, such as commodity, infrastructure and water sector. Among the alternative sectors, water industry has been achieving strong and steady growth. It profits from the growth of

world economy; and dynamics such as urbanisation and water shortage have also caused its prosperity (Pinsent Masons, 2010). Hence, the increased interest in the water sector in recent years should not come as a surprise.

The traditional approach for investors to participate in the water sector is to directly purchase equities of water companies. However, recently other forms of financial instruments have been introduced allowing more choices for investors to gain exposure to the water market. Water indices and the related ETFs are vehicles developed to mirror the market in meeting investors' needs to take positions in the whole water market rather than in a specific water company. They offer investors the flexibility of buying and selling the whole water market with a single transaction.

The American Stock Exchange (AMEX) introduced the Palisades Water Index (ZWI) in 2003 and started publishing it on a regular basis since 2005 (Geman & Kanyinda, 2007). Following the publication of ZWI, two ETFs – Power Shares Water Resources and Power Shares Global Water – were successively introduced to investors to assist them in keeping track of companies included in the ZWI (Keenan, 2008). As such, there are other ETFs available to investors, for example, Claymore S&P Global Water which is based on the S&P Global Water Index, and First Trust ISE Water which is based on the ISE Water Index (Atkinson, 2009). However, a number of companies included in these water indices generate only a small portion

of their revenues from water-related products and/or services. Questions were raised as to whether these water ETFs can be defined as pure water funds (Kearney, 2008).

Dow Jones and the SAM group (SAM is a Swiss firm that specialises in sustainable asset management) collaboratively introduced WOWAX in 2006. WOWAX is comprised of 20 of the largest publicly traded companies in the water-related business worldwide. Specifically, the comprised companies are required to have their primary source of revenues in one or more water investment clusters, such as water utilities, water infrastructure and water treatment (Societe Generale, 2006). In the meantime, the French bank Societe Generale, Dow Jones Indexes and SAM launched a certificate SAM sustainable Water Fund replicating the performance of this index, providing investors access to the water industry via WOWAX. The Dutch bank ABN Amro offers a similar product – the ABN ‘Water Certificaat’ which is also directly related to WOWAX (Geman & Kanyinda, 2007). As WOWAX only includes companies specialising in water-related business, it is considered an accurate representation of the water market industry. Therefore, it is chosen to be the tool of examining the water market as a whole.

Investments in the water indices and EFTs and their diversification potential in combination with other asset classes have not yet been studied to the best knowledge of the authors. Geman and Kanyinda’s (2007) study is perhaps the best

attempt in this field. Their study focuses on the possibility of trading water as a commodity, and taking direct positions in future contracts and structured notes. Specifically, they evaluate the performance and volatility of WOWAX between December 2003 and June 2006, and find that the index increased by more than 80% during this period. Meanwhile, the volatility is remarkably low (consistently lower than 12% for more than half year from December 2005 to August 2006). In addition, they review WOWAX's performance in relation to the three major commodity investments (i.e., Dow Jones-AIG total return index, Dow Jones-AIG Energy Sub-index and Dow Jones-AIG Petroleum Sub-index). Their results indicate that WOWAX outperformed Dow Jones-AIG total return index, which itself was a particularly successful investment since its start in 2000. Consequently, Geman and Kanyinda's (2007) suggest WOWAX and hence the water sector a good investment choice. However, their study is not without flaws. First, due to the recency of WOWAX, they only examine its performance for the first two and a half years of its life, which is clearly insufficient to draw valuable conclusions. Second, the authors do not investigate the existing water market in-depth, but briefly review the performance of the two water indices (i.e., ZWI and WOWAX). Third, there has been little discussion on stocks of water-related companies and water index. Fourth, they fail to examine the profitability of these indices from different perspectives. For example, this paper could additionally explore the relationship between the water asset class and traditional investment asset classes, and the diversification benefits of

the water asset class in a portfolio context. Geman and Kanyinda's study contributes to our understanding of the profitability of water investments. However, the results of their study have marginal value in guiding investors in decision making. Moreover, research on water investments post the financial crisis is generally lacking. The present study aims to fill in this gap.

4.3. Issues and Hypotheses

The water market is characterised by stable growth rates and high dividend ratios (Doerr, 2008). Investors generally believe that water assets can provide them with desirable risk-return trade-offs, which seems to be the driving force of current private water investment. However, empirical evidence is lacking in supporting the intuition. Hence, the first hypothesis is formulated as follows:

Hypothesis 4.1: Investments in WOWAX provide attractive risk-return combinations to investors.

The modern portfolio theory first developed by Markowitz (1952) states that the risk correlations between various assets and optimal allocation of capitals are of foremost importance to investors. Usually, a low or negative correlation is favoured because it provides better diversification effects and reduces the overall portfolio risk to a minimal level.

As water industry is monopolistic in nature and the incomes of water firms tend to remain comparatively stable (OECD, 2009a), the water market is not likely to be easily affected by volatility of economic conditions. It is widely believed that the water asset class might have weak relationships with traditional asset classes such as stocks and bonds (Berlant, 2009). Therefore, the second hypothesis aiming to understand this very relationship emerges as:

Hypothesis 4.2: WOWAX has low correlations with traditional asset classes (i.e., stocks and bonds).

For an alternative investment asset, high risk-adjusted returns or low correlations with other portfolio components alone do not guarantee an enhanced performance of the portfolio. Before choosing an alternative asset, investors need to examine how the additional component(s) might affect the overall portfolio performance. Therefore, to test the risk-return trade-offs of portfolios containing WOWAX, the third hypothesis is formulated as follows:

Hypothesis 4.3: Adding WOWAX into traditional portfolios will enhance the portfolios' performance.

4.4. Research Design

4.4.1. Data Sample

In order to assess the profitability of water investment and its diversification potential, it is necessary to first identify the traditional asset classes that are already available to investors. In an ideal investment world, investors are assumed to invest their capitals in a well-diversified stock portfolio and in a well-diversified bond portfolio. In this study the stock portfolio will be represented by the MSCI World Index (MSCIWI), a market capitalisation weighted stock index maintained by the MSCI Inc., which is known as a benchmark for world stock funds. The Barclays Global Aggregate Index (BGAI) – a broad based bond index maintained by Barclays Capital will be chosen to represent the global bond market performance.

WOWAX will be employed to reflect economic activity in the water sector. This index is maintained by the Dow Jones Index and the SAM Group; it aggregates the performance of 20 major listed water company stocks, and thus represents a diversified and liquid investment instrument that investors can apply to take a long or short position for water sector exposure (Societe Generale, 2006). Moreover, this index is an equally weighted benchmark; that is, the weight of each member is set at 5% to maintain an efficient diversification. To keep the index updated, WOWAX is rebalanced every quarter, and its composition is assessed on a semi-annual basis (Societe Generale, 2006).

The data used for this study will include daily returns on the three representative indices of the stock, bond and water markets, respectively, for the period between 1st January, 2004 and 31st May, 2012. This time period is selected because WOWAX can only be traced back to as far as the beginning of 2004. All the indices employed in this study are performance indices and on a U.S. dollar basis. The data are obtained through *DataStream* and from the website of Societe Generale.

4.4.2. Key Variables and Test Statistics

For all the indices, continuously compounding returns are calculated. The return is the natural log return on the index at time t , while $\Delta p_{i,t}$ denotes the rate of change of $p_{i,t}$ (Campbell, 2008):

$$\Delta p_{i,t} = \ln \left(\frac{p_{i,t}}{p_{i,t-1}} \right) \times 100 \quad (4.1)$$

Expected return on portfolio R_p :

$$R_p = \sum_{i=1}^n W_i \mu_i \quad (4.2)$$

where

W_i = Weights of investment i

μ_i = Mean return on investment i

Standard deviation of the portfolio σ_p :

$$\sigma_p = \sqrt{\sum_{i=1}^n w_i^2 \sigma_i^2 + \sum_i \sum_j^n w_i w_j \text{Cov}_{ij}} \quad (4.3)$$

where

w_i^2 = Weights of the individual assets in the portfolio

σ_i^2 = Variance of the return on asset i

Cov_{ij} = Covariance between the return on asset i and j

According to Sharpe (1966), a portfolio's risk-return characteristic can be measured through the Sharpe ratio. A higher Sharpe ratio is associated with higher portfolio efficiency. Gibbons, Ross and Shanken (1989) develop a significance test to compare the Sharpe ratios of more than one portfolio. Given the Sharpe ratios of the two portfolios (i.e., the base one and the enhanced one) S_B and S_E , the following null hypothesis is testable:

$$H_0: S_E = S_B$$

According to Gibbons *et al.* (1989), this hypothesis can be assessed by the following test statistic:

$$W = \left[\frac{\sqrt{1+S_E^2}}{\sqrt{1+S_B^2}} \right]^2 - 1 \quad (4.4)$$

where

S_B = The Sharpe ratio of the base portfolio

S_E = The Sharpe ratio of the enhanced portfolio

The W statistic is a non-negative number because $S_E \geq S_B$. Under the null hypothesis, W is equal to zero, which implies that the two portfolios have similar mean-variance efficiencies. A large W means that one portfolio outperforms another in a statistically significant manner, which leads to rejection of the null hypothesis and

the conclusion that the mean variance efficiencies of the two portfolios are significantly different.

The W statistic follows a Wishart distribution, and can be transformed into an F – distribution:

$$\frac{T(T-N-1)}{N(T-2)} W \sim F_{N,(T-N-1)} \quad (\text{given that } S_E > S_B \geq 0 \text{ and } T/N \geq 3) \quad (4.5)$$

where

T – Number of observations

N – Number of assets

The transformation only applies when $S_E > S_B \geq 0$ holds (i.e., W must be non-negative). It should also be noted that the power of the test is critically affected by the degree of freedom of the F -test, as Gibbons *et al.* (1989) suggest that the ratio T/N must meet a threshold of $T/N \geq 3$ for the test to be sensitive. This technique can be used to test whether the Sharpe ratio of a mean-variance efficient portfolio is significantly greater than that of a naively constructed portfolio (Cheng and Liang, 2000).

4.5. Empirical Results

4.5.1. Summary Statistics of Key Variables

We use daily return data from 1st January 2004 to 31st May 2012 (101 months) for the following three indices: MSCIWI, BGAI and WOWAX. By standardising all the time series to 100, Figure 4.1 shows that generally, the MSCIWI and the WOWAX present with similar trajectories during the sample period, while the BGAI appears flat.

Figure 4.1 Standardised Indices from January 1, 2004 to May 31, 2012

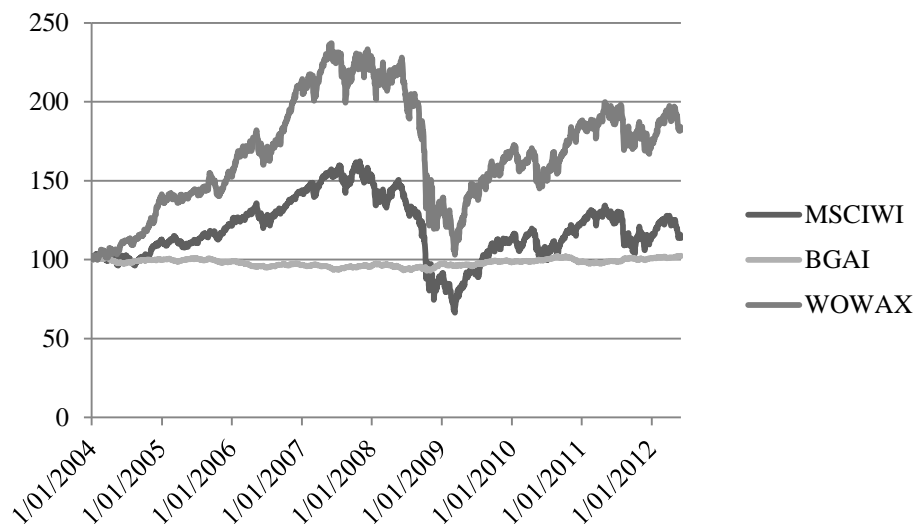


Table 4.1 illustrates the descriptive statistics for the daily rates of return on WOWAX. The standard deviation of WOWAX's return was 1.1652%, indicating a moderate level of risk. Table 4.1 also reveals a negative skew of -0.223 and a kurtosis of 8.7, indicating that a large proportion of the returns resulted from outlying returns. The Kolmogorov-Smirnov test results reject the null hypothesis and suggest that the distributions of the daily returns on the three indices were not normal ($p < 0.001$).

Table 4.1 Descriptive Statistics of Returns

Statistic	MSCIWI	BGAI	WOWAX
N	2195	2195	2189
Mean	0.0058%	0.0011%	0.0274%
Minimum	-7.3250%	-0.7108%	-7.4366%
Maximum	9.0967%	0.7289%	10.9850%
Stand. Dev.	1.1487%	0.1633%	1.1651%
Skewness	-0.446	-0.066	-0.223
Kurtosis	8.7	1.148	8.7
Kolmogorov-Smirnov	4.472**	1.679**	3.707**

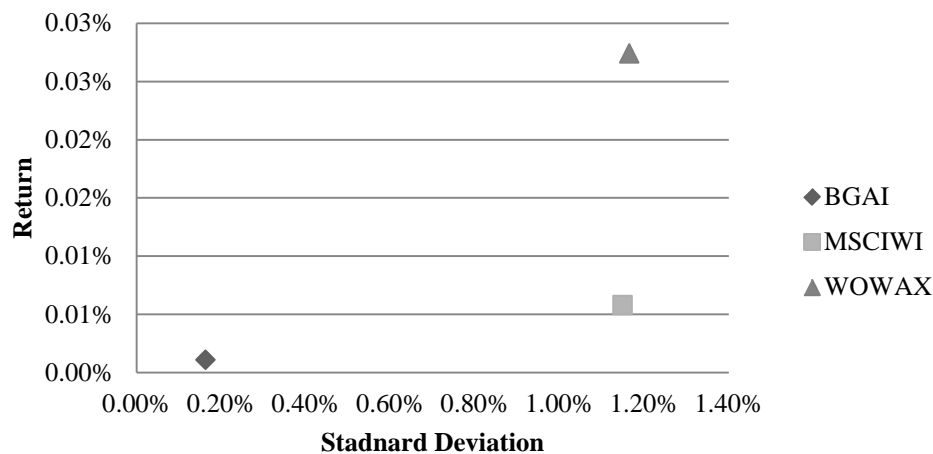
*Note: ** means significant at the 1% level.*

4.5.2. Hypothesis 4.1 – Risks and Returns

To test Hypothesis 4.1, the WOWAX is measured against the MSCIWI and the BGAI in terms of risk and return. As shown in Table 4.1, the average daily rate of return on WOWAX (0.0274%) is much higher than that on MSCIWI (0.0058%). The bond asset offers even lower mean return as the BGAI exhibits a daily return of 0.0011%. It is worth noting that both the lowest and highest daily returns of the MSCIWI and BGAI occur in the second half year of 2008. This is likely to be the result of the abnormal movements (i.e., GFC) in the financial world during that period. However, no such pattern surface in the water sector. This could be a good sign when exploring the diversification effects of WOWAX.

Risk of the assets is positively correlated with their returns. The risk-return trade-offs of the three indices are depicted graphically as shown in Figure 4.2. As expected, BGAI displays both low return and risk. WOWAX which substantially outperforms MSCIWI with only a little added risk is deemed to be more attractive.

Figure 4.2 Daily Risk Returns on Asset Classes



For the following analyses, the overall sample period of 101 months are then divided into three sub-periods as it includes the great financial crisis between August 2007 and December 2008 (Hatemi-J & Roca, 2011). Accordingly, the first sub-period ranges from January 2004 to July 2007 including a bull market; the second sub-period from August 2007 to December 2008 including the great financial crisis; and the third sub-period from January 2009 to May 2012 which is post the great financial crisis. The daily rates of return on all the three indices vary substantially across the sample period. Their means and standard deviations for the three sub-periods are reported in Table 4.2.

Table 4.2 Means and Standard Deviations for the Three Sub-periods

Sub-period	Statistics	Index		
		MSCIWI (%)	BGAI (%)	WOWAX (%)
Period 1	Mean	0.0442	-0.0059	0.0836
	Stand. Dev.	0.5871	0.1411	0.7337
Period 2	Mean	-0.1433	0.0079	-0.1281
	Stand. Dev.	1.8053	0.2217	1.8412
Period 3	Mean	0.0277	0.0056	0.0334
	Stand. Dev.	1.2351	0.1562	1.1663

Note: Sub-period 1: January 2004 to July 2007; Sub-period 2: August 2007 to December 2008; Sub-period 3: January 2009 to May 2012.

The differences between MSCIWI, BGAI and WOWAX are analysed using t-tests. Results in Table 4.3 indicate that there are no statistically significant differences between the three indices except for Sub-period 1 where BGAI significantly underperforms the other two indices.

Table 4.3 T-Test Results on the Returns on the Three Industry Indices from January 2004 to May 2012

	MSCIWI – BGAI	MSCIWI – WOWAX	BGAI – WOWAX
Full Sample Period			
<i>t</i> -value	0.191	-0.619	-1.049
df	4388	4382	4382
<i>p</i> -value	0.849	0.536	0.294
Sub-period 1			
<i>t</i> -value	2.538	-1.281	-3.662
df	1864	1864	1864
<i>p</i> -value	0.011*	0.200	0.000**
Sub-period 2			
<i>t</i> -value	-0.1601	-0.113	1.412
df	740	740	740
<i>p</i> -value	0.110	0.910	0.158
Sub-period 3			
<i>t</i> -value	0.529	-0.100	-0.705
df	1780	1774	1774
<i>p</i> -value	0.597	0.920	0.481

Note: * significant at the 5% level, and ** significant at the 1% level.

Based on the above results, the following conclusions can be made. First, for the full sample period, the rates of return on WOWAX are on average much higher than those on equity indices. This may be partly due to the outperformance of WOWAX within the first sub-period. This finding confirms the previous findings which suggest the water assets generate higher returns than listed stocks (Geman & Kanyinda, 2007). Second, the equity and water indices generally trounce the bond index. Because of the turbulence that affected the entire financial world, both MSCIWI and WOWAX performed poorly during Sub-period 2, with both of their average daily rates of return falling by about 0.2%. In the meantime, the average daily rate of return on the bond index increases considerably. Lastly, in the past four years after the financial crisis, WOWAX presents lower levels of risks but higher average

daily rates of return than MSCIWI. It is noteworthy that although there are apparent differences in returns, these differences do not reach statistical significance. This is possibly because our study utilises daily returns where the values are very small and standard deviations are incomparably large.

It can be seen in Table 4.1 that in the full sample period WOWAX generates a higher average daily rate of return than MSCIWI, but also bears a higher risk. Despite the individual preferences of investors with different degrees of risk aversion, it is undeniable that WOWAX outperforms MSCIWI where its average daily rate return is more than five times higher than that of MSCIWI, but its risk is nearly equal to that of MSCIWI. These results lend support to Hypothesis 4.1 stating that investments in WOWAX provide attractive risk-return combinations to investors.

4.5.3. *Hypothesis 4.2 – Correlations*

Recall that Hypothesis Two centres on how returns on the WOWAX vary in relation to traditional portfolios (e.g., the combination of the MSCIWI and the BGAI). If the WOWAX displays low levels of correlation with the MSCIWI, the BGAI, and/or their combinations, we consider it as having good diversification potential.

In order to determine the relationships between the three asset classes, the Pearson's correlation analysis is applied to examine whether their correlation values

are significantly different from zero. Table 4.4 presents the results of correlations between the water, equity and bond indices.

Table 4.4 Pearson Correlations of Daily Returns

	Correlation Coefficients		
	MSCIWI	BGAI	WOWAX
Full Sample Period			
MSCIWI	1	-0.301**	0.873**
BGAI		1	-0.235**
WOWAX			1
Sub-period 1			
MSCIWI	1	0.007	0.736**
BGAI		1	0.129**
WOWAX			1
Sub-period 2			
MSCIWI	1	-0.353**	0.898**
BGAI		1	-0.331**
WOWAX			1
Sub-period 3			
MSCIWI	1	-0.417**	0.899**
BGAI		1	-0.371**
WOWAX			1

Note: ** indicates that correlation is significantly different from zero at the 0.01 level.

Table 4.4 indicates that WOWAX significantly correlates with BGAI in a negative manner and with MSCIWI in a positive manner. These relationships appear to have strengthened over time.

The strong association between WOWAX and MSCIWI is initially thought to be partly due to the fact that WOWAX is comprised of stocks of 20 water companies, of which many may have also been included in MSCIWI. However, as MSCIWI consists of more than 1,000 components, its strong correlation with WOWAX cannot be entirely explained by the fact that the latter is also part of the former. In addition, according to Figure 4.1 and Table 4.2, the two indices' performances appear to be

relatively similar. Hence, the diversification effect of WOWAX to MSCIWI asset is doubtful.

Despite the co-movement of WOWAX and MSCIWI, the low correlation between WOWAX and BGAI is encouraging, for it provides WOWAX a diversification potential.

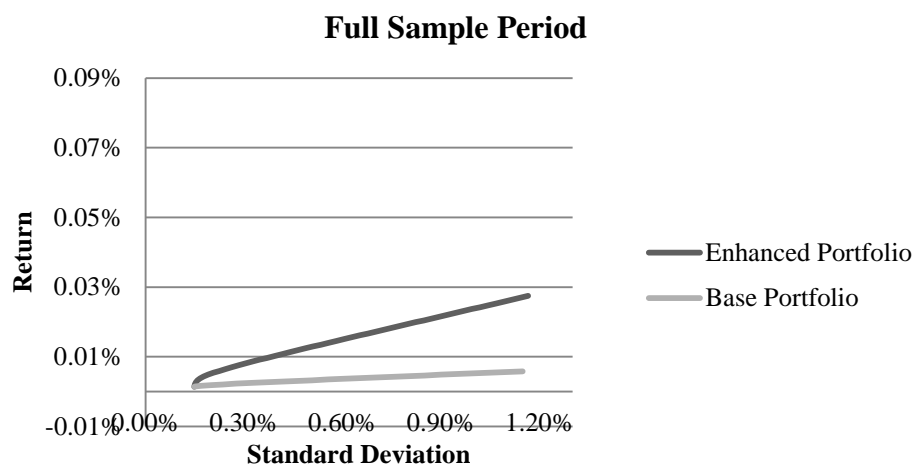
Consequently, at this stage of analysis, the results only partially support Hypothesis Two which states that WOWAX has low correlations with traditional investment asset classes. In fact, WOWAX is significantly negatively correlated with BGAI, but significantly positively correlated with MSCIWI. This finding casts some doubts on the assumption that investing in stocks of water companies can bring investors diversification benefits.

4.5.4. *Hypothesis 4.3 – Diversification Effects*

To seek a better understanding of the risk-return profile of WOWAX in a portfolio context, the efficient frontiers which integrate the covariance of the assets as well as the overall variations and expected returns are calculated.

Two portfolios are created: a base portfolio which is made up of two traditional asset classes (i.e., MSCIWI and BGAI), and an enhanced portfolio which additionally includes WOWAX. For both portfolios, all efficient combinations of assets are modelled to create the efficient frontiers. The results are presented in Figure 4.3.

Figure 4.3 Efficient Frontier Analyses – Full Sample Period

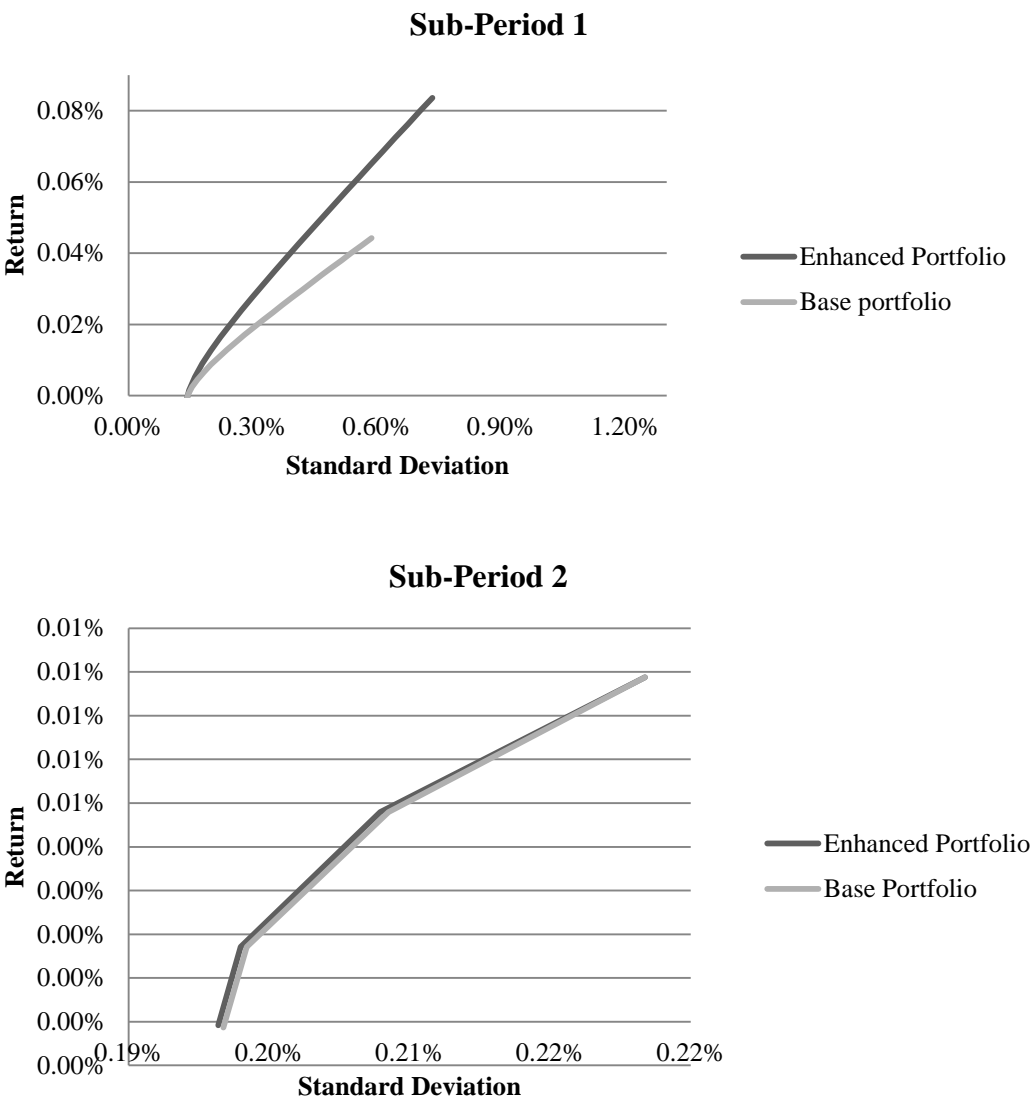


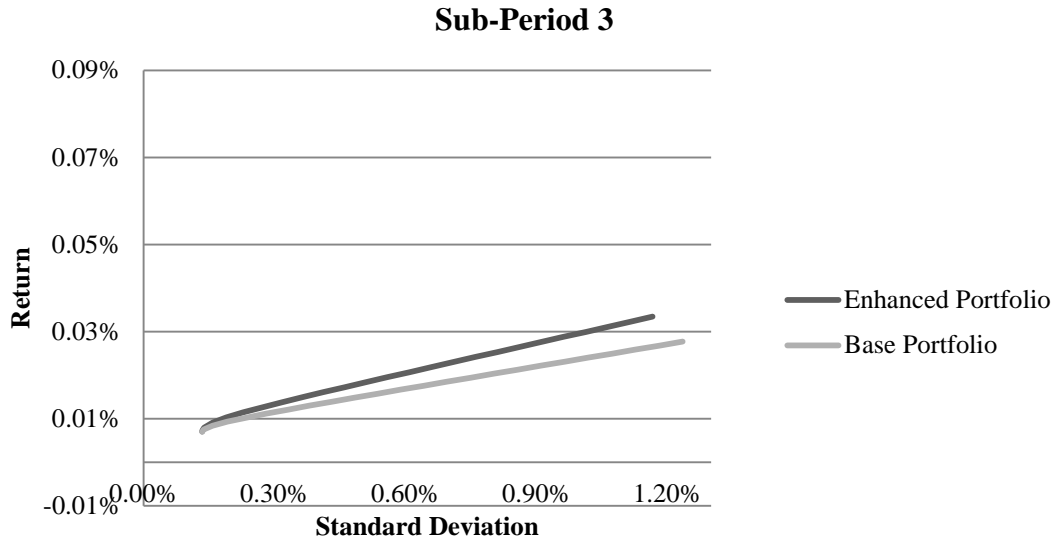
From Figure 4.3, it can be seen that the portfolios which optimally combine assets offer improved risk-return trade-offs for MSCIWI and BGAI. It is also found that the efficient frontier of the enhanced portfolio consistently dominates that of the base portfolio, and that there is an apparent disparity between the two efficient frontiers. This suggests that the enhanced portfolio continually generates a higher return than the base portfolio at a given level of risk. Given the results, it can be concluded that during the time period of investigation, participation in the water industry yields diversification gains even to investors who have already held globally diversified portfolios in the stock and bond markets. Despite WOWAX's strong correlation with MSCIWI, it provides considerable diversification benefits, mostly due to its low correlation with the bond index.

Afterwards, efficient frontiers of the two portfolios in the three sub-periods are created (Figure 4.4) where similar results are observed in Sub-periods 1 and 3. The exception occurs during the financial crisis (Sub-period 2). As MSCIWI and WOWAX fail to generate positive returns, BGAI accounts for the largest portion of the efficient combinations of both base and enhanced portfolios. Hence, WOWAX

shows limited diversification effects for the base portfolio, and the efficient frontiers of both portfolios overlap greatly.

Figure 4.4 Efficient Frontier Analyses – Three Sub-Periods





In this study, it is assumed that mean historical returns are representative of expected returns and that investors can borrow and invest at the risk-free rate (T-bill rate). Hence, the Sharpe ratios of the base and enhanced portfolios, and F-statistics of these Sharpe ratios are calculated to assess the diversification effects of WOWAX in the following analyses. In order to further evaluate the diversification benefits, optimising and comparing the base and enhanced portfolios are also necessary. The subsequent analyses perform portfolio optimisations. The returns, standard deviations, and optimal portfolio weightings of the indices are reported in Table 4.5, so that a comparison of base and enhanced portfolios can be made in terms of the benefits. Moreover, considering that the enhanced portfolios contain WOWAX whose return is not distributed normally (see Table 1), the standard deviation alone is not sufficient to measure the riskiness of the portfolios. The value at risk (VaR) and conditional value at risk (CVaR) at the 95% confidence level are calculated, which helps to measure the downside risks (Krokhmal, Palmquist & Uryasev, 2002).

Table 4.5 Diversification Properties of WOWAX for Different Sample Periods

	Base Portfolio	Without Limitation in WOWAX	10% in WOWAX	20% in WOWAX	30% in WOWAX
Panel A: Full Period					
Return	0.0026%	0.0222%	0.0048%	0.0070%	0.0092%
Stand. Dev.	0.3396%	0.9248%	0.3438%	0.3674%	0.3881%
Sharpe Ratio	-0.0124	0.0167	-0.0058	0.0007	0.0063
VaR	0.5580%	1.4793%	0.5644%	0.5855%	0.6196%
CVaR	0.7002%	1.8574%	0.7089%	0.7359%	0.7791%
F-Statistic		N/A	N/A	N/A	N/A
W% MSCIWI	31%	0%	22%	14%	5%
W% Barclays	69%	20%	68%	66%	65%
W% WOWAX	0%	80%	10%	20%	30%
Panel B: Sub-period 1					
Return	0.0442%	0.0836%	0.0482%	0.0521%	0.0561%
Stand. Dev.	0.5868%	0.7333%	0.5842%	0.5858%	0.5917%
Sharpe Ratio	0.0539	0.0968	0.0608	0.0674	0.0734
VaR	0.9167%	1.1163%	0.9085%	0.9072%	0.9128%
CVaR	1.1593%	1.4188%	1.1500%	1.1494%	1.1574%
F-Statistic		2.0030	0.2479	0.5079	0.7688
W% MSCIWI	100%	0%	90%	80%	70%
W% Barclays	0%	0%	0%	0%	0%
W% WOWAX	0%	100%	10%	20%	30%
Panel C: Sub-period 2					
Return	0.0079%	0.0079%	0.0079%	0.0079%	0.0079%
Stand. Dev.	0.2214%	0.2214%	0.2214%	0.2214%	0.2214%
Sharpe Ratio	0.0014	0.0014	0.0014	0.0014	0.0014
VaR	0.3562%	0.3562%	0.3562%	0.3562%	0.3562%
CVaR	0.4485%	0.4485%	0.4485%	0.4485%	0.4485%
F-Statistic		0.0000	0.0000	0.0000	0.0000
W% MSCIWI	0%	0%	0%	0%	0%
W% Barclays	100%	100%	100%	100%	100%
W% WOWAX	0%	0%	0%	0%	0%
Panel D: Sub-period 3					
Return	0.0197%	0.0276%	0.0205%	0.0215%	0.0223%
Stand. Dev.	0.7683%	0.9092%	0.7645%	0.7769%	0.7797%
Sharpe Ratio	0.0253	0.0300	0.0265	0.0273	0.0283
VaR	1.2308%	1.4473%	1.2324%	1.2397%	1.2525%
CVaR	1.5465%	1.8185%	1.5487%	1.5580%	1.5742%
F-Statistic		0.0769	0.0178	0.0319	0.0471
W% MSCIWI	64%	0%	55%	47%	38%
W% Barclays	36%	21%	35%	33%	32%
W% WOWAX	0%	79%	10%	20%	30%

Note: The critical value of F at the 5% significance level is around 2.6 and all the reported F -statistics are smaller than 0.5. Thus, p -values are not calculated.

Results from the optimisation of the base and enhanced portfolios are illustrated in Table 4.5. Panel A depicts the optimised portfolios of the full period, in which the base portfolio is made up of 31% of MSCIWI and 69% of BGAI. As expected, the enhanced portfolio's return greatly improves when it includes WOWAX additionally (the daily return of the optimal risky portfolio increases from 0.0026% to 0.0222%). Without surprise, the improvement of return comes with an augment of the portfolio's volatility, i.e., the standard deviation rise from 0.3396% to 0.9248%. To provide a clear risk profile, Table 4.7 also compares the tail risks and reports the VaR and CVaR estimated at the 95% confidence level. Panel A shows that the tail-risk of the optimal portfolio increases after adding WOWAX into the combination (VaR increases from 0.558% to 1.479%, CVaR increases from 0.700% to 1.857%). This is because WOWAX has a larger downside risk (lower VaR and CVaR) than MSCIWI and BGAI. However, these extra risks seem to be compensated by the increasing returns. The Sharpe ratio increases considerably from -0.0124 to 0.0167, suggesting the existence of diversification benefits. Unfortunately, due to the negative Sharpe ratio of the base portfolio, Gibbons et al.'s (1989) significance test could not be applied in this situation. The F-statistics which allows one to evaluate whether the enhanced portfolios significantly improves the efficiency of the base portfolio are not available in Panel A.

It is worth noting that after optimisation, WOWAX has a weighting of 80% in the enhanced portfolio. In reality, the participation in water sector should be no more than a supplement to a widely diversified portfolio. Hence this portfolio composition (80% WOWAX, 20% BGAI and 0% MSCIWI) may not be an appropriate recommendation. In order to gain a more realistic valuation, the enhanced portfolio is

optimised again with the weightings of WOWAX limited to 10%, 20% and 30% individually. When the weighting of WOWAX is limited to 10%, the optimal enhanced portfolio consists of a 22% stake in MSCIWI and a 68% stake in BGAI. Compared with the base portfolio, this enhanced portfolio's return increases by 86% but the risk does not increase correspondingly. The standard deviation, VaR and CVaR remain almost unchanged. This suggests that by adding 10% of WOWAX into the base portfolio, investors could enjoy the diversification benefit without extra risks. As the weighting of WOWAX segmentally increases in the portfolio to 20% and then 30%, the returns and risk of the portfolios increased accordingly. The same pattern is observed in the Sharpe ratios. These findings are consistent with the results in the previous analyses, indicating that a more advantageous risk-return combination can be achieved by supplementing a base portfolio with WOWAX. It is also noted that the weighting of BGAI remains stable during the optimisation process, while MSCIWI is replaced by WOWAX gradually. This is likely attributable to the low correlation between BGAI and WOWAX, and high correlation between MSCIWI and WOWAX.

Panels B, C and D are arranged identically to Panel A, displaying the same analyses repeated for three sub-periods. According to Panel B, the optimal portfolios in Sub-period 1 are comprised without BGAI. It is noted that the optimal base portfolio is formed purely by MSCIWI, and the optimal enhanced portfolio is consisted exclusively of WOWAX. BGAI has a zero stake in all five optimised combinations. These observations are believed to be products of the negative return of the BGAI, and the strong association between WOWAX and MSCIWI.

Panel C portrays the performance of portfolios in Sub-period 2 (the financial crisis period). Both MSCIWI and WOWAX have negative mean returns during the 17 months, while BAGI is the only profitable asset. As a result, all optimised combinations in Sub-period 2 are entirely consisted of BAGI. Although WOWAX outperforms MSCIWI in the financial crisis, it still could be abandoned.

Portfolio optimisation for Sub-period 3 is shown in Panel D. Compared with MSCIWI, WOWAX generates higher returns but has lower risk in the after crisis period. It can be seen that the weight of BGAI is kept stable while MSCIWI is replaced by WOWAX incrementally during the process. This trend leads to growth in the returns, Sharpe ratios and F-statistics.

Overall, the four panels in Table 4.5 consistently show that with the increase of the weight of WOWAX, the portfolios' returns and Sharpe ratios increase correspondingly. This indicates that the risk-return trade-offs of the portfolios improves as it includes more shares of water investments. The enhanced performance of portfolio is likely to be resulted from the superior risk-return combinations provided by WOWAX as well as its low correlation with BGAI. However, the diversification effect of WOWAX is weakened by its strong positive correlation with MSCIWI.

F-statistics are used to examine the statistical difference between the Sharpe ratios of base and enhanced portfolios in three sub-periods (F-statistics not available for the full sample period). Unfortunately, all available F-statistics are too small to be significant (compared with the critical F-value of 2.6 at a 5% significance level),

suggesting that there is no statistically significant difference. This finding was in line with the result found by the first significance test (which was illustrated in Table 4.3). Nonetheless, in Panels A and B, Sharpe ratios of traditional portfolios increase considerably by including WOWAX as an additional component, which is believed to be of economic significance. This discrepancy may cause investors to hesitate in making investment decisions. According to Michael et al. (2009), economic significance should be granted priority over statistical significance. Hence, it is recommended that in the consideration of forming a well-diversified investment portfolio, investors give priority to the economic significance of adding WOWAX into their portfolios.

Based on the present findings, we can conclude that Hypothesis 4.3 stating that adding WOWAX into traditional portfolios will enhance the portfolios' performance is supported by the results. However, the evidence fails to reach statistical significance, and the diversification effects are stronger before the 2008 financial crisis.

To summarise, it is safe to say that WOWAX can be used as a substitute of MSCIWI in a portfolio, but not a replacement for BGAI. Table 4.5 indicates that when MSCIWI is incrementally replaced by WOWAX, the returns on the portfolios increase and to a certain level, the risk decreases. However, there are no such effects when BGAI are replaced by WOWAX.

4.6. Conclusions

We compare the performance of a water index and the listed equity and bond indices, with the purpose of investigating the profitability of water-related investments and their diversification benefits in a portfolio context. The motivation for our study is derived from the need to understand whether or not water indices and water funds are desirable tools for investment; that is, whether investors can profit from investing in the water industry.

Overall, our findings suggest that the water asset class, or more specifically, WOWAX outperforms the traditional asset classes between 2004 and 2012, and has the capacity to yield diversification effects in portfolios primarily comprised of listed equity and bond assets. These results confirm Geman and Kanyinda's findings in 2007 where they report that WOWAX generates higher returns but lower risks than listed stocks. Our results are also consistent with the belief that the water sector can be considered as an alternative investment asset class because of its stable growth rates, high dividend ratios and low correlations with traditional asset classes (Berlant, 2009; Doerr, 2008). However, these analyses are not exactly conclusive: the study also shows that the relationship between the water asset class and listed equity class might not be as low as it was thought previously, and the diversification benefits of WOWAX may not be significant during and after the financial crisis

period since 2007. Hence, investors should be mindful of these issues when making investment decisions.

In contrast to the more established alternative asset classes such as private equity and real estate, research on water investments is scarce. Our study contributes to closing this research gap and expands our knowledge on the returns and the diversification properties of water investments. However, it is limited by the sampling. WOWAX is selected to represent the water asset class. Apparently, a single index cannot track the performance of the whole water market, and focusing exclusively on the performance of WOWAX during the seven years might have weakened the utility of this study. Therefore, investigation on other water-related assets (water stocks, indices and ETFs), of which data can be traced back further may provide us with a more comprehensive understanding of the water market.

Chapter 5 Water as an Investment: Liquid yet Illiquid!³

Water assets are believed to be affected by various risks. According to financial theories, if a risk is unable to be diversified away, investors in the industry should earn a risk premium. Therefore, one of the main concerns in making water investment decisions is about whether an appropriate risk premium can be earned. However, the influences of these risks on water assets are implausibly under-studied, which may have played a part in the disagreements between water investors and government institutions.

An asset pricing model accurately describing the risk and return profile of the water industry can help to set a benchmark for returns on water assets. Unfortunately, few attempts have been made to apply such models to water assets (Antoniou et al., 2001). Among all of the risks faced by the water industry, asset-in-place management ranks as one of the top risks. Being a primary infrastructure industry, water companies typically own and maintain a crucial amount of fixed assets-in-place. This type of assets is not readily convertible into cash and hinders the operating flexibility of companies in responding to different market conditions and competition. In other words, water companies are faced with the so-called

³ This chapter includes a paper that is currently under revision: Jin, Y., Roca, E., Li, B., & Wong, V. (Under Revision). Water as an investment: Liquid yet illiquid! *Applied Economics Incorporating Applied Financial Economics*. Statement of Contribution as a co-author can be found in pages x-xv.

‘liquidity risk’. It is of interest to learn whether investors in the industry are able to earn extra returns (or risk premium) as a compensation for this illiquidity factor. This study examines the effect of liquidity risk on the returns on water companies and aims to answer two questions: (a) whether asset liquidity risk affects the stocks returns on companies operating in the water industry; and (b) whether asset liquidity risk varies across firms and over time.

5.1. Introduction

Water is a vital commodity, essential to life, agriculture and industry. The water industry is one of the largest industries in the world. It plays a significant role in today’s economies. Resources devoted to it dwarf those in most other sectors (Berg and Marques, 2010). It is estimated that the size of the global water industry today is between USD 425 billion and USD 700 billion per year, and these numbers are projected to grow considerably in the next decades (Geman and Kanyinda, 2007). Nevertheless, this industry is still suffering from the problem of underinvestment. Specifically, more than one billion people living in developing countries have limited or no access to sanitary drinking water (Organisation for Economic Co-operation and Development, 2009a). The OECD countries are also faced with significant financial challenges of maintaining and updating water infrastructures and of improving management efficiency.

As a result of the great need for funding as well as a good prospect of growth, the water industry has quickly become a hot space in the past decade. There has been an increasing interest in the concept of investing in the water – water is often touted as the ‘blue gold’. Unlike products such as oil, wheat and metal, water is not usually traded on the market as a commodity. Hence, investing in water companies and water stocks has been the most commonly adopted approach as alternative to direct investment in water as a commodity. In this context, water indices have been created to meet the needs of investors who are interested in this market. These indices are designed to assist investors in capturing movements of the water market. Built on the water indices, water funds are also now available for investors looking for opportunities in this market. For instance, the American Stock Exchange introduced the Palisades Water Index (ZWI) in December 2003 and began to publish this index on a regular basis from August 2005. Following the publication of the ZWI, two water funds – Power Shares Water Resources and Power Shares Global Water – were formed to assist investors in keeping track of companies included in the ZWI. Since March 2012 these two funds have been re-constructed to track the NASDAQ OMX Water Index.

Knowledge on the risk and returns associated with the water industry is crucial in water investors’ decision making. However, the extant literature on water investment does not reflect the significance of the water industry. Few investment

institutions have placed their research focus on this industry; scholarly research on the profitability of water investments is generally lacking. Even the existing academic literature so far provides little knowledge on the risk and returns of water investments. This has become a barrier to attracting private investments which is urgently needed by the water industry. Our paper contributes to the scant literature by examining the impact of asset liquidity (or illiquidity risk) on stock returns from the water industry.

Being a primary infrastructure industry, water companies typically own and maintain a crucial amount of fixed assets-in-place. As explained in more details later, this kind of assets is not readily convertible into cash and also hinders the operating flexibility of these companies in responding to different market conditions and to competition. These companies, therefore, face what is termed as liquidity risk and it is thus of interest to learn whether investors in the industry are able to earn extra returns (or risk premium) as a compensation for this illiquidity factor. In this study, we examine the effect of liquidity risk on the returns of water companies, controlling for other factors that are known to affect returns as identified in the Fama-French (1992 and 1993) three-factor model and using panel regression. Specifically, we address two questions: (a) whether asset liquidity risk affects the stocks returns of companies operating in the water industry; and (b) whether asset liquidity risk varies across firms and over time.

Our results suggest that asset illiquidity is positively associated with stock returns. The association remains significant after controlling for other factors that affect returns such as beta, size, and book-to-market ratio. Specifically, water firms with a larger proportion of illiquid assets-in-place are observed to have higher stock returns than those with a smaller proportion of illiquid assets. We conclude that an asset illiquidity effect exists in water company stocks and is not influenced by the presence of other factors that affect returns such as market factors, or stock characteristics. These results imply that if investors are to be enticed to participate in the water industry, then returns in the industry should compensate them also for the liquidity risk that is inherent in the industry in addition to other non-diversifiable investment risks such as those relating to the market, firm or project, etc.

The remainder of our paper proceeds as follows. Section 5.2 examines the relevant literature while Section 5.3 discusses the data and methodology. Section 5.4 presents the empirical results of the panel data analyses using the Fama-French three-factor model and our liquidity-augmented asset pricing model. Section 5.5 provides the conclusion of the study.

5.2. The Water Industry

Using the water industry as a context for the study enables us to contribute to the further understanding of liquidity risk. As mentioned, the water industry is one

that is saddled with illiquid assets and hence, like other industries with the same characteristic, is expected to face liquidity risk. However, unlike other industries that also have liquidity risk, it has the unique features of having a commodity that is deemed to be vital and a “public good”, in short supply relative to demand, and hence, often, its price is controlled by regulatory authorities. Therefore, the results of the study can provide further evidence on liquidity risk coming from a different setting. We provide a detailed discussion in the ensuing paragraphs to illuminate this uniqueness of the water industry.

Water is an essential commodity. Yet, it is in severe shortage, in spite of the fact that the earth is mostly covered with water. More than 2.6 billion people are living in areas affected by severe water stress. Distressingly, these numbers are still growing and are expected to reach 3.9 billion by 2030 (Organisation for Economic Co-operation and Development, 2008). It is claimed that the insufficiency of water infrastructure, largely caused by financing gaps in the water industry, is considered to be an important contributing factor to global water shortage (Wild et al., 2007).

Even if there are severe water shortages, the existing global water industry is already enormous. White et al. (2010) report that the world’s market for water-related equipment and operation was more than USD 480 billion in 2010, while Summit Global Management (2012) estimate the number is near USD 700 billion

per year. In contrast, in the same year, the world's IT market was USD 650 billion, the Cell Phone market was USD 600 billion, Pharmaceuticals were USD 450 billion, and Telecom Equipment was USD 300 billion (White et al., 2010). In spite of the huge size of the existing market, the water sector is still suffering from budget deficits and scarce funding resources in general. According to OECD (2009b), the water service investments in developing countries need to be doubled. For instance, the United States Environment Protection Authority (2002) estimates a USD 27 billion funding gap every year simply for the supply of clean and drinking water in the US. The USEPA has not provided further data after 2002; however based on the survey conducted by American Water Works Association (2011), this financing gap may still exist as a large proportion of US water infrastructure has reached or will soon reach the end of its lifespan, and at least USD 1 trillion will be required to restore existing water system by 2035. Data on the other countries are even more vague and speculative. According to OECD (2009b), France and the United Kingdom need to increase their spending on water by 20%; while Japan and Korea need to expand these investments by more than 40% in order to maintain water services at an acceptable level.

As stated above, it is widely acknowledged that more financial resources should be allocated and brought into the water industry. Unfortunately, research on the profitability of water investments is generally lacking, and investors are ill-

informed about the performance of the water industry. This situation hinders private capital from participating in the water market. It is therefore important to understand, through methodologically stringent studies, the risk-adjusted returns on water investments. In other words, we believe that the transparency of risk and return trade-offs of water industry will potentially interest more investors in the water industry, contributing to closing the financing gap in the industry.

Among all of the risks faced by the water industry, asset-in-place management ranks as one of the top risks. The water industry is highly regulated by authorities and is required to conform to community expectations (MacGillivray et al., 2006). Water businesses spend a large amount of funds to ensure the performance of essential fixed assets-in-place such as underground pipes, sewer networks, and water storage facilities. Given its significance, asset-in-place has been extensively considered in both strategic and program operating risk analyses. Valuing assets-in-place is the most basic valuation of an ongoing business for the purpose of informing decisions. Water companies, especially water utility companies, consider the value of assets-in-place as a critical determinant in their resource allocation decisions, which is in turn a key driver of their overall performance (Maxwell, 2009).

The United Nations Environment Programme Finance Initiative (2006) points out very clearly that water investments are exposed to a high level of asset risk due to the capital intensity nature of this industry. The water industry typically requires large investments and a high proportion of capital on fixed assets, and it is known as one of the three largest industries in the world (along with Oil & Gas and Electricity) in terms of embedded capital (Summit Global Management, 2012). Olstein et al. (2009) calculate the capital intensity ratio (the ratio of assets to revenues) of different industries. They note that the water industry is even more capital intensive than other infrastructure industries such as electricity, gas and telecommunication. In addition to the capital intensity, UNEPFI (2006) points out that investments required to provide water services are often long-lived and irreversible. The investments on fixed assets cannot be readily converted into cash. Once the investments are made, they cannot be reversed should the returns from the investments prove less than expected.

In other words, the most distinctive feature of the water industry is its asset illiquidity and the associated high liquidity risk. According to finance theories, if a risk is unable to be diversified away, then investors in the industry should earn a risk premium. Hence, one of the big questions in making water investment decisions is whether an appropriate risk premium can be earned, given its characteristic of asset illiquidity.

5.3. Literature Review

5.3.1. Research on Risk and Returns of Water Investment

There are a number of studies on the risk and returns of water industry; however, most of these papers focus on policymaking issues. For example, Renzetti and Dupont (2003) examine the relevance of ownership to performance of water utilities and suggest that ownership structure does not have an impact on performance. Sirtaine et al. (2005) point out that granted water concessions are not necessarily able to generate adequate returns for water utilities. Certain business oriented questions are also addressed. It is also argued that the performance of water companies is affected by their size, diversification and geographical location with differing degrees of significance (Shaoul, 1997; Guerrini et al., 2011; Kim and Lee, 1998). However, rather than assessing returns from the financial market, research testing the profitability of water industry predominantly rely on financial statements of water businesses, calculating financial ratios and a range of cost functions. Few studies have attempted to analyse the riskiness of water investments or price water stocks from the perspective of investors in the financial market. To our best knowledge, this paper is the first to examine the impact of the industry specific characteristics on water stock return, and more specifically the effect of asset in place risk on the returns of water stocks.

5.3.2. *Asset-In-Place Risk*

Modigliani and Miller (1958); Modigliani and Miller (1963) propose that equity returns result from a firm's asset risk and financial risk. They contend that asset risk increases as book leverage decreases, and that financial risk increases with market leverage. Fama and French (1992) find a stock return anomaly related to book-to-market ratio, namely book-to-market effect or value effect. That is, the return on value firms (firms with a high book-to-market ratio) is, on average, higher than that of firms with growth option (firms with a low book-to-market ratio). Fama and French (1992) do not explain the underlying reasons behind the value effect, but interpret the book-to-market ratio as market leverage (measures of capital structure based on the market value of equity) scaled by book leverage (measures of capital structure based on the book value of equity). In equation form, this idea can be expressed as follows:

$$\text{Book Equity} / \text{Market Equity} = [\text{Debt} / \text{Market Equity}] / [\text{Debt} / \text{Book Equity}].$$

Integrating the ideas of Modigliani and Miller (1958); Modigliani and Miller (1963) and Fama and French (1992), Peterkort and Nielsen (2005) argue that the book-to-market ratio can be viewed as a combined measure of asset risk and financial risk. Holding the other variables constant, a decrease in book leverage (increase in asset risk) or an increase in market leverage (increase in financial risk) is associated with both a higher book-to-market ratio and a higher required return on

equity. The above equation can therefore be transformed into: *Book Equity / Market Equity* = *Asset Risk* × *Financial Risk*, implying that stock return is positively associated with both asset risk and market risk. To test this theory, Peterkort and Nielsen (2005) apply both leverage factors to an augmented Fama-French three-factor model as additional risk factors. Their results show a positive relationship between market leverage and average returns and a negative relationship between book leverage and average returns, lending support to their hypothesis. Interpreting most of the book-to-market effect as a leverage effect, Peterkort and Nielsen (2005) contend that asset and financial risk factors provide a possible explanation for the previously unexplained book-to-market factor in the Fama-French three-factor model. In specific, they conclude that Fama and French (1992)'s book-to-market effect is brought on by financial risk and, to some extent, asset risk. This argument is supported by Dempsey (2010) who replicates Peterkort and Nielsen's (2005) study using the Australian data. Dempsey (2010) provides further evidence indicating that asset risk explains book-to-market risk and captures most movements of stock returns.

Peterkort and Nielsen (2005) build a connection between the value effect and asset risk based on their mathematical relationship, while Zhang (2005) puts forward another asset-risk-based explanation for the value effect relying on the distinctive feature of asset risk itself – low reversibility. It is argued that disinvestment of

assets-in-place is difficult resulting in irreversibility or illiquidity. Fixed assets have greater risk exposure than growth options, especially during economic contractions (Petkova & Zhang, 2005; Zhang, 2005). This notion establishes a link between a firm's book-to-market ratio and its asset illiquidity and explains why growth firms (low book-to-market firms) receive lower returns.

Following Zhang (2005)'s work, Cooper (2006) develops a real option model that describes this link in detail. He argues that firms with high book-to-market ratios (i.e., value firms) are usually those that have invested in a large proportion of installed capital capacity. Due to the costly process of reversing assets-in-place, capital investment of such firms is relatively constant. In economic distress, a firm with a high proportion of physical assets typically generates a large amount of idle capacity, leading to a decreasing market value. Meanwhile, its book value remains almost unchanged. As a result, the firm's book-to-market ratio is likely to increase under these circumstances. Both Cooper (2006) and Zhang (2005) reach the conclusion that high returns on value firms (high book-to-market firms) come from the illiquidity of fixed capital investment.

On the other hand, the same firm with a large proportion of fixed assets can better utilise a booming period, given that the idle capacity can be employed to increase production output without the need for further investment. Comparatively,

growth firms with few installed physical assets tend to have low book-to-market ratios and often have a lag in acquiring assets to take advantage of the positive shocks. It may indicate that the effects of asset illiquidity and book-to-market ratio on stock returns are even related to business cycle (Copper, 2006). In general, value stocks are riskier than growth stocks in economic distress, whereas growth stocks are riskier than value stocks when the economy is expanding. Copper's (2006) theory is corroborated by Petkova and Zhang (2005) and Zhang (2005) who find that value firms have counter-cyclical betas, while growth firms have pro-cyclical betas.

Inspired by these works, Docherty et al. (2011); Docherty et al. (2010) adopt asset tangibility as a proxy of investment irreversibility and examine its relationship with stock returns in the Australian context. They apply the Fama-French three-factor model within both time-series and cross-section frameworks. Using long-time series analyses to capture multiple business cycles, Docherty et al. (2010) find significantly higher premiums earned by firms with a larger proportion of tangible assets than those with a smaller proportion of tangible assets. These premiums are maintained after controlling for both size and book-to-market factors, indicating that the tangibility factor captures some variation not explained by the Fama-French three-factor model. Docherty et al. (2010) then conclude that the explanatory power of the model increases when augmented with an additional variable representing asset irreversibility.

In addition to the time-series analyses, Docherty et al. (2011) test the existence of tangibility factor in a cross-sectional framework using the Fama and MacBeth (1973) method. A significant positive relationship between stock return and tangibility ratio is reported when regressions are estimated for the overall market, providing further support to their study in 2010. However, they point out that this association is largely driven by microcap stocks, for small and large firms do not show this characteristic. Moreover, after controlling for industry representation, the premium earned on firms with a higher proportion of tangible assets is limited only in the materials industry. Docherty et al. (2011) explain that this is because tangible assets in the materials industry are more firm-specific than those in any other sectors, making investments in that sector highly irreversible.

Gopalan et al. (2012) examine the illiquidity of assets-in-place from a different angle. They point out that since a firm's stock is a claim on cash flows generated by its underlying assets, the liquidity of the firm's stock should reflect the liquidity of the underlying assets. After measuring the cross-sectional correlation between asset liquidity and stock liquidity using the Fama-Macbeth (1973) approach, Gopalan et al. (2012) find supporting evidence demonstrating a strong positive correlation between asset illiquidity and stock illiquidity in the US market. Given the ample evidence showing the important role of stock illiquidity in the prediction

of stock returns (Acharya and Pedersen, 2005; Amihud and Mendelson, 1986), it is reasonable to postulate an interaction between asset illiquidity and stock returns.

As mentioned above, the water industry is perhaps the most capital intensive industry in the world, with a large proportion of illiquid and tangible assets-in-place. The investment irreversibility theories proposed by Petkova and Zhang (2005) and Copper (2006) provide a good approach to investigating the industry-specified risk factors of water stocks. We, therefore, hypothesise that there is an asset liquidity/illiquidity risk (premium) in the equities of water businesses; that is, stock return increases as asset liquidity decreases. We also hypothesise that book-to-market ratio is partly accounted for by an asset liquidity factor. We attempt to identify this asset liquidity factor in the following sections.

5.4. Methodology and Data

We determine the role of the liquidity factor in explaining returns of firms in the water industry. Based on Fama (1992 and 1993), we control for the effects of other factors that affect stock returns such as beta (also called market or systematic risk), size (capitalisation of the firm) and value of the firms (proxied by book-to-market ratio), which have been proven in the literature to be good predictors of stock returns. It is well-established in the literature that returns are positively related to market risk and value of the firm but negatively related to size.

Analogous to Docherty et al. (2011), we use four regressions to test the relationship between returns and asset liquidity, beta, size and book-to-market ratio.

$$r_{it} = \alpha_0 + \gamma_{1t}\text{Beta}_{it} + \gamma_{4t}\text{Asset Liquidity}_{it} + e_{it} \quad (5.1)$$

$$r_{it} = \alpha_0 + \gamma_{1t}\text{Beta}_{it} + \gamma_{2t}\text{Ln}(\text{Size})_{it} + \gamma_{4t}\text{Asset Liquidity}_{it} + e_{it} \quad (5.2)$$

$$r_{it} = \alpha_0 + \gamma_{1t}\text{Beta}_{it} + \gamma_{3t}\text{Ln}\left(\frac{\text{BE}}{\text{ME}}\right)_{it} + \gamma_{4t}\text{Asset Liquidity}_{it} + e_{it} \quad (5.3)$$

$$r_{it} = \alpha_0 + \gamma_{1t}\text{Beta}_{it} + \gamma_{2t}\text{Ln}(\text{Size})_{it} + \gamma_{3t}\text{Ln}\left(\frac{\text{BE}}{\text{ME}}\right)_{it} + \gamma_{4t}\text{Asset Liquidity}_{it} + e_{it} \quad (5.4)$$

where r_{it} is the portfolio return; Beta_{it} , $\text{Asset Liquidity}_{it}$, $\text{Ln}(\text{Size})_{it}$, and $\text{Ln}(\text{BE}/\text{ME})_{it}$ represent systematic risk, asset liquidity ratio, firm size and book-to-market ratio of the portfolio, respectively. The regressions investigate into the joint explanatory power of all variables and evaluate the relationship between asset liquidity and return. If investment irreversibility is a risk factor, the coefficient on the asset liquidity variable should be significant after controlling for the beta, size, and book to market factors. Furthermore, if the association between asset liquidity and return is pervasive, the coefficients on these variables should be significant across the sample.

Market value of equity or size is calculated as the number of issued shares multiplied by the market share price. Similarly, book value is computed as the number of issued shares multiplied by the book value per share. For each company included in the sample, market equity is collected annually at the end of financial year (year $t-1$) when used to compute book-to-market ratio, and six months after the

conclusion of that financial year when used to measure its size (year t). This is to avoid a look-ahead bias and to ensure that accounting variables are known before they are used to explain returns. This conservative six-month delay in the use of accounting data is consistent with previous studies (e.g., Fama and French (1992) and Docherty et al. (2011)).

For our analyses, we use the MSCI World Index as the market portfolio and the LIBOR one month rate as a risk-free proxy. We estimate betas for stocks in the sample, similar to Amihud and Mendelson (1986). In particular, at the end of every year, all stocks are sorted into five quintile portfolios based on their individual beta rankings. Once the portfolios are formed and the betas for each portfolio are computed, we assign the beta of a portfolio to all the stocks in that portfolio. By estimating betas at a portfolio level, we reduce potential measurement errors that may occur in estimating betas at an individual firm level.

Docherty et al. (2010) measure the asset illiquidity degree as the ratio of tangible asset to the book value of equity (tangible asset / book value). However, we consider fixed assets as a more appropriate proxy than tangible assets. This is because tangible assets include highly liquid current assets, and intangible assets such as goodwill are, in effect, highly irreversible. Moreover, Docherty et al. (2010, 2011) use book value as the denominator in their calculation of asset illiquidity.

This is likely to increase the risk of multicollinearity as book-to-market is also included in their regression analyses. Additionally, given the classification of tangibility, more than half of their samples have no intangible assets, resulting in a highly skewed data set. To avoid these disadvantages, we adopt fixed asset instead of tangible asset in the numerator and total asset instead of book value of equity in the denominator. We create asset liquidity ratios as follows:

$$\text{Asset Liquidity Ratio}_{i,t} = \frac{\text{Fixed Asset}_{i,t}}{\text{Total Asset}_{i,t-1}} \quad (5.5)$$

We create portfolios to examine the relationships among asset liquidity, book-to-market (BE/ME), and average return. We divide the returns into four BE/ME quartile portfolios in each sampling year. We then sort each BE/ME quartile portfolio into four asset liquidity sub-quartile portfolios, resulting in 16 portfolios each year. We calculate the average value of monthly returns for each portfolio in each year. This double-sort procedure is similar to that used by Fama and French (1992) and is intended to show patterns of asset liquidity that are independent of variation in the primary sort variable (BE/ME). Unlike linear regression tests, the results from these double-sort portfolios do not assume any specific functional form for the relationships among the variables.

Panel data analysis is used because it accounts for both cross-sectional and time-series effects while controlling for unobserved factors affecting water

industry's systematic risk. Specifically, four different approaches are used. The first approach is a simple pooled Ordinary Least Square (OLS) regression with the assumptions of homogeneous variance and no serial correlation. This approach is similar to cross-sectional method and may lead to omitted variable bias due to unobserved firm characteristics. The second approach is a one-way (firm) fixed effects regression. It assumes that each firm has its own individual characteristics which may influence the independent variables. The firm fixed effects regression controls the effects of those time-invariant characteristics, and thus the estimated coefficients cannot be biased. In the third approach, we control not only firm effects but also time effects. This approach yields a two-way (firm and time) fixed effects regression. Lastly, the fourth approach assumes the variation across firm and time to be random and uncorrelated with the independent variables in the model. In this case, a random-effects model is used to estimate the coefficients. In addition, we perform a series of analyses to test the significance of the firm and time effects in the data set in order to choose a reliable model for our studies.

Our study sample consists of all the 76 firms (see Appendix 5.1) that comprise the five most representative global water indices – ISE Water Index, NASDAQ OMX Global Water Index, NASDAQ OMX US Water Index, S&P Global Water Index, and the World Water Index. The selected water indices are composed of publicly traded companies that have been active in the global water

industry. These companies have a balanced representation from different segments of the water industry such as utilities, infrastructure, water treatment, and industrials. The global water industry is enormous but dominated by a small number of international companies such as Veolia, Suez, and RWE-Thames (United Nations Human Settlements Programme, 2003). The majority of the sampled companies are considered as the biggest players in their chosen segments. Therefore, by including the 76 water companies, our sample serves as a good benchmark of the global water market.

The biggest bulk of the 76 companies are US companies. In order to homogenise returns, prices of all other stocks are converted into US dollars using bilateral foreign exchange rates. The same holds for the other variables such as size and book-to-market ratio. As such, we observe the stocks from the point of view of a US dollar-denominated investor.

We obtain panel data for all the 76 firms during the period of 1st July 2001 to 31st December 2012 (13-year period) from DataStream. We choose to only utilise the recent data for two reasons. First, due to excessive fragmentation, the industry has undergone a considerable amount of consolidation with a great deal of merger and acquisition activities in the last decade (Berlant, 2009). Some water firms have become defunct, while others have re-appeared following a merger. This has led to

considerable difficulty in collecting consistent data. Second, the water industry has become an increasingly important investment choice in the past twenty years. The majority of the water indices on the market were formed in or can only be traced back to 2001-2003. The sample contains daily stock returns, stock prices, and various financial data on balance sheets.

5.5. Empirical Results

Panel A of Table 5.1 presents descriptive statistics for return, beta, size, BE/ME, and asset liquidity ratio based on monthly observations. Consistent with Fama and French (1992), we take the natural log of size and BE/ME. None of these variables have outliers during the sample period of this study. To investigate the relationships between each of the five variables of water firms, we produce a correlation matrix covering the whole sample period. Panel B provides the results of the correlation analyses. The strongest correlation (-0.298) in this study is that between beta and asset liquidity ratio. It suggests that from a univariate point of view, there is a mild tendency for companies with a smaller proportion of fixed assets to have a higher systematic risk. However, we find that none of the other correlations (the absolute value) is greater than 0.2. The magnitude of the correlations between the variables indicates that multicollinearity seems not to be a problem in this study.

Table 5.1 Descriptive Statistics and Correlation Matrix**Panel A. Descriptive Statistics**

	Mean	Median	Std. Dev.	Min	Max
Average monthly return	0.004	0.010	0.123	-1.399	1.385
Beta	1.165	1.109	0.913	-1.056	3.409
Ln(Size)	13.523	13.758	1.805	4.599	17.640
Ln(BE/ME)	-0.779	-0.819	0.709	-5.160	2.705
Asset Liquidity	0.337	0.234	0.289	0.002	1.980

Panel B. Correlation Matrix

	Return	Beta	Ln (Size)	Ln(BE/ME)	Asset
Return	1.000				
Beta	-0.021	1.000			
Ln (Size)	0.044	0.150	1.000		
Ln(BE/ME)	0.053	-0.003	-0.147	1.000	
Asset	0.028	-0.298	-0.196	-0.028	1.000

Notes: Panel A reports summary statistics for all variables used in the analyses. Panel B reports the correlations between these variables. For each month from 2000 to 2012, the correlations between the variables are calculated, and the time-series averages are reported.

Further analysis reveals a number of interrelations between the variables.

The size and BE/ME are negatively correlated (-0.147), suggesting that larger water firms tend to have smaller book-to-market ratios, while smaller firms are more likely to have higher book-to-market ratios. This negative relation is consistent with Fama and French (1992). It is noteworthy that both size and BE/ME are correlated with return in a positive manner. This result is surprising because it is generally expected that size and BE/ME contain different information about average return. On the same note, asset liquidity is negatively correlated with size and BE/ME; yet, asset liquidity, size and BE/ME have positive correlations with average return. Hence, the relation between asset liquidity ratio and return cannot be drawn by simply observing the correlation matrix.

We next examine the effect of asset liquidity by classifying the sampled firms into five quintile portfolios based on their asset liquidity ratios. Firms that have the smallest proportion of fixed assets are allocated to the first quintile (the high asset liquidity ratio portfolio), while firms that have the largest proportion of fixed assets are allocated to the fifth quintile (the low asset liquidity ratio portfolio). Portfolios are rebalanced annually in December, and then the annual means of return, size, BE/ME and asset liquidity ratio are calculated for each portfolio. This procedure enables us to demonstrate the relationships between asset liquidity ratio and return, as well as the other variables. Based on Cooper (2006) and Zhang (2005)'s theory of investment irreversibility, we hypothesise that firms with a higher level of illiquidity should earn more returns than those with a lower illiquidity level. As such, we expect a positive relationship between asset liquidity ratio and stock return.

Table 5.2 presents our portfolios sorted based asset liquidity ratios. The spread between returns on the five asset liquidity portfolios is 0.442% (from 0.265% to 0.707%). This spread is significantly different from zero, indicating the variance of returns on these portfolios. However, the returns vary as the value of asset liquidity ratios increases or decreases, but do not display a discernible pattern across the portfolios. That is, we fail to observe a significant relationship between asset liquidity and stock return in the present study. This finding is inconsistent with

Docherty et al.'s (2011) univariate sorting analysis result, which shows a strong link between intangibility and return. We believe that the lack of significant relationship may be due to two reasons. The asset liquidity effect may be offset by the other variables. Besides return, neither BE/ME nor size appears to be associated with asset liquidity, suggesting that the asset liquidity ratio is not affected by the BE/ME and size variables. Second, water privatisation has gradually become available in the past twenty years, but has been dominated by a small number of big players. The industry has experienced a substantial amount of consolidation in the last ten years. Its short trade history and excessive fragmentation have led to a small dataset, making it difficult to observe significant relationships.

Table 5.2 Variables Sorted Based on Asset Liquidity Ratio

	High Liquidity Portfolio	2	3	4	Low Liquidity Portfolio
Asset	0.089	0.160	0.241	0.387	0.848
Return	0.007	0.003	0.007	0.003	0.003
Ln (Size)	13.588	13.791	13.829	13.470	12.737
Ln(BE/ME)	0.662	0.524	0.611	0.688	0.480

Notes: This table reports summary statistics for water firms sorted on asset liquidity ratio. For each year from 2000 to 2012, firms were sorted into five portfolios. The average of each variable is calculated for each year, and time-series averages for each of these portfolios are reported in the table. The first column reports the characteristics of firms that have the lowest proportion of fixed assets; the final column reports the characteristics of firms with the highest proportion of fixed assets.

Both Peterkort and Nielsen (2005) and Docherty et al. (2011) have indicated in their studies that BE/ME is related to the asset liquidity risk of a firm. The correlation matrix in Table 5.1 displays a negative relation between BE/ME and asset liquidity, which tends to blur the connection between asset liquidity and stock

return. To minimise the inter-relations between variables, we control for the BE/ME ratio by employing the double-sort analysis described above. Table 5.3 shows the results. It is theorised that holding BE/ME constant, the average return tends to increase with raising asset liquidity ratio. However, no discernible pattern is found in the average monthly return across the portfolios. Even though the average returns on the lowest liquidity sub-portfolios are generally greater than those on the highest liquidity sub-portfolios, the relation is clearly not linear. This result indicates that the linearity assumption does not hold, and there is no specific functional form for the relation between asset liquidity and return in this case.

Table 5.3 Monthly Returns for Portfolios Formed on Book-to-Market and Asset Liquidity Ratios

	BE/ME			
	Low	2	3	High
High Liquidity	0.427	-0.152	0.698	0.289
2	-1.309	0.259	0.586	1.037
3	0.504	0.352	0.018	-0.109
Low Liquidity	-0.828	0.746	0.765	0.907

Notes: This table reports returns on asset liquidity sub-portfolios. In December of each year from 2000 to 2012, all firms are sorted into four BE/ME quartile portfolios. Each yearly BE/ME quartile portfolio is then sorted into four asset liquidity sub-portfolios. Finally, the time-series averages for each of these portfolios are reported.

Using panel data analysis, we regress stock returns on explanatory variables as specified in Equations (5.1) to (5.4). Results of the estimation for all water stocks in the study are displayed in Table 5.4. Panel A reports the equations estimated by the pooled OLS method. It is noted that the results of the pooled regressions do not support our prediction. In particular, the slope coefficients of beta and asset liquidity factors are not significant across the sample, indicating that the two variables have

no explanatory power for the returns on water stocks. This is contrary to our hypothesis that a larger proportion of illiquid assets would have a positive effect on stock return. It is noteworthy that our panel data set is comprised of different cross sections over time and is likely to give rise to heterogeneity. The pooled OLS regression is based on the assumption that the errors in each time period are uncorrelated with the explanatory variables in the same time period. Moreover, it does not take into account individual heterogeneity. Therefore, the simple pooled OLS regression tends to lead to biased estimations. Due to this shortcoming, we believe that both the generalised least square fixed effects and random effects models are better choices than the pooled OLS regression because they correct for the omitted variable bias and presence of autocorrelation and heterogeneity in pooled time series data.

Table 5.4 Coefficient Estimates from Panel Regressions of Average Monthly Return on Beta, Ln(Size), Ln(BE/ME), and Asset Liquidity (World Water Stocks)

Model	Intercept	Beta	Ln(Size)	Ln(BE/ME)	Asset Liquidity	Adj. R ²	Chi-Sq.
Panel A. Ordinary least square regression							
1	0.0013 (0.46)	-0.0020 (-1.36)			-0.0009 (-0.19)	0.000	
2	-0.0467** (-4.52)	-0.0270** (-1.83)	0.0035** (4.85)		0.0028 (0.58)	0.003	
3	0.0087** (2.68)	-0.0019 (-1.30)		0.0098** (5.45)	-0.0002 (-0.03)	0.003	
4	-0.0479** (-4.64)	-0.0027* (-1.86)	0.0042** (5.77)	0.0115** (6.28)	0.0044 (0.93)	0.007	
Panel B. Firm fixed effects model							
1	-0.0008 (-0.07)	-0.0024 (-1.45)			0.0224** (2.14)	0.000	6.22**
2	-0.3908** (-11.19)	-0.0037** (-2.24)	0.0241** (11.75)		0.0280** (2.69)	0.014	121.29**
3	0.0257** (2.27)	-0.0019 (-1.12)		0.0247** (8.98)	0.0336** (3.21)	0.007	57.33**
4	-0.4274** (-12.27)	-0.0032** (-1.96)	0.0284** (13.75)	0.0317** (11.45)	0.0433** (4.17)	0.028	215.11**
Panel C. Firm and time fixed effects model							
1	0.0307 (0.82)	-0.0038** (-2.49)			0.0204** (2.06)	0.195	18.99**
2	-0.3954** (-7.52)	-0.0043** (-2.85)	0.0268** (11.48)		0.0092 (0.93)	0.207	130.13**
3	0.0451 (1.20)	-0.0035** (-2.27)		0.0187** (6.82)	0.0324** (3.23)	0.199	37.99**
4	-0.3953** (-7.55)	-0.0040** (-2.62)	0.0277** (11.93)	0.0206** (7.54)	0.0219** (2.20)	0.212	150.13**
Panel D. Random effects model							
1	0.0014 (0.46)	-0.0020 (-1.36)			-0.0009 (-0.19)		
2	-0.0467** (-4.52)	-0.0027* (-1.83)	0.0035** (4.85)		0.0027 (0.58)		
3	0.0087** (2.68)	-0.0019 (-1.30)		0.0098** (5.45)	-0.0002 (-0.03)		
4	-0.0479** (-4.64)	-0.0027* (-1.86)	0.0042** (5.77)	0.0115** (6.28)	0.0044 (0.93)		

Notes: This table reports the coefficients on the panel regressions. In each month from January 2000 to December 2012, panel regressions are used to estimate Equations (5.1) to (5.4). The associated *t* statistics are reported in parentheses under the relevant coefficients. * $p < 0.10$, ** $p < 0.05$.

Panels B and C provide the results for the one-way and two-way fixed effects regressions, respectively. These results portray a different picture from the pooled regressions. We find that nearly all observed factors – including betas and asset liquidity ratios – display a significant relationship with the return on water stocks across the sample. In Panel B, the asset liquidity factor displays a positive and

significant slope coefficient in an augmented capital asset pricing model CAPM model (Regression 5.1). Moreover, the coefficient on the asset liquidity variable retains its positive relationship with return and remains highly significant for all the firm fixed effects regressions in Panel B, even after controlling for size and the book-to-market effect. This result is consistent with our hypotheses. It suggests that a water firm employing a larger (or smaller) proportion of illiquid assets tends to have a greater (or smaller) degree of investment irreversibility, as well as a higher (or lower) expected return. This finding is partially corroborated by Docherty et al. (2011).

The firm and time fixed effects regressions in Panel C display similar results in that the asset liquidity factor demonstrates a positive relationship with return. Interestingly, we find the strength of the models (the adjusted R^2) is greatly improved after controlling for the time effects. It may suggest that the overall variation of water firms' return is due to error representing unexplained year-to-year changes.

The least square dummy variable model is adopted to test the significance of the firm and time effects in the data set. The results show that most dummy variables (firms and months) are significant, suggesting the existence of both firm and time effects (Detailed results are not provided but available upon request due to limited

space). The fixed effects model is therefore considered to be a better approach than the pooled OLS regression for this study because the pooled regression does not capture differences among firms and over time.

In addition to the fixed effects regressions, we use random effects regression to further investigate the relative power of asset liquidity in explaining the variation of water stock returns. The results are presented in Panel D. Furthermore, the Hausman specification test is conducted to determine which of the two approaches (fixed effects and random effects) is more suitable for our estimation models. We find significant Chi-square statistics for all eight tests, indicating that the null hypothesis of an equality of fixed and random effects regressions is rejected at the five per cent significance level. It means that the error term of the estimation is correlated with the observed variables and provides support for the fixed effects regression model over the random effects model. Consequently, we focus on the two fixed effects approaches. We present estimates from the pooled OLS and the random effects models as a comparison.

As shown in Table 5.4, Panels B and C, the results of fixed effects regressions demonstrate that the asset liquidity factor plays an important role in explaining stock returns on water firms. Cooper (2006) suggests that asset irreversibility is related to the book-to-market ratio. Docherty et al. (2010) argue that

asset irreversibility may be superior to book-to-market ratio. However, our results do not support the superiority of asset irreversibility. We examine asset liquidity ratio and BE/ME in Equation (5.3), and find that both variables have positive and significant slope coefficients. Although they both predict stock returns, they are unable to capture all the risk characteristics represented by each other. Equation (5.4) is an augmented Fama-French three-factor model, aiming to examine whether the liquidity effect persists after controlling for the variables in the three-factor model. Comparing Equations (5.2) and (5.4), we find the strength of asset liquidity effect in Equation (5.2) is not reduced by the presence of BE/ME, but increases to some extent in Equation (5.4). The coefficient on the asset liquidity factor retains its positive relationship with return and remains highly significant with the inclusion of BE/ME. The explanatory power of the regression is increased (with increased statistical significance and magnitude) when all the explanatory variables are combined.

We interpret this result as an important piece of evidence of Cooper (2006)'s notion that the investment irreversibility should be priced in equity return. In our study, the illiquidity of assets plays an important role in explaining water stock returns; that is, a higher proportion of illiquid assets leads to a higher return. It may be because the returns on water firms that invest in a large amount of assets-in-place co-vary more strongly with market returns across business cycle (Docherty et al.,

2011). In the augmented Fama-French model (Equation 5.4), the asset liquidity factor does not absorb the explanatory power of book-to-market factor when both factors are included in the regressions, and vice versa. This indicates that the asset liquidity factor does not represent the same risk as the book-to-market factor, but explains variation in stock returns that is not captured by the Fama-French three-factor model. In other words, although the asset liquidity factor does not have the same extent of explanatory power as BE/ME, it contains small but significant additional information about return.

Considering that the US water firms make up nearly 50% of the total sample, we divide the sample into two groups – the US water stocks and non-US water stocks. We repeat the procedures discussed above and conduct a robustness check. Results are reported in Tables 5.5 and 5.6. As can be seen in Table 5.5, analyses based on the US water stocks produce almost the same results as those based on the overall sample. For example, the fixed effects models are also found to be the most appropriate form of analysis for the US data set. The asset liquidity variable generally shows a positive relationship with stock return after controlling for the Fama-French pricing factors. The direction and magnitude of the slope coefficients of the asset liquidity ratio in the US data set are consistent with the findings from the overall sample, suggesting that asset liquidity has a predictive value in explaining the returns on water stocks.

Table 5.5 Coefficient Estimates from Panel Regressions of Average Monthly Return on Beta, Ln(Size), Ln(BE/ME), and Asset Liquidity (US Water Stocks)

Model	Intercept	Beta	Ln(Size)	Ln(BE/ME)	Asset Liquidity	Adj. R ²	Chi-Sq.
Panel A. Ordinary least square regression							
1	0.0041 (1.02)	-0.0027 (-1.38)			-0.0041 (-0.71)	0.000	
2	-0.0936** (-4.93)	-0.0015 (-0.76)	0.0066** (5.27)		0.0069 (1.12)	0.006	
3	0.1329** (2.84)	-0.0032 (-1.61)		0.0098** (3.91)	-0.0036 (-0.62)	0.003	
4	-0.1106** (-5.77)	-0.0018 (-0.91)	0.0086** (6.67)	0.0148** (5.66)	0.0112* (1.80)	0.013	
Panel B. Firm fixed effects model							
1	-0.0053 (-0.47)	-0.0021 (-0.95)			0.0488** (2.29)	0.000	7.58**
2	-0.5472** (-9.83)	-0.0034 (-1.60)	0.0334** (9.94)		0.0515** (2.45)	0.021	80.17**
3	0.0209* (1.73)	-0.0014 (-0.66)		0.0251** (5.71)	0.0647** (3.03)	0.007	26.64**
4	-0.6129** (-10.98)	-0.0028 (-1.30)	0.0398** (11.62)	0.0368** (8.27)	0.0754** (3.57)	0.035	120.43**
Panel C. Firm and time fixed effects model							
1	-0.0888 (-0.93)	-0.0048** (-2.53)			0.0581** (3.12)	0.301	6.61**
2	-0.5912** (-5.27)	-0.0039** (-2.05)	0.0346** (8.28)		0.0316* (1.68)	0.312	49.84**
3	-0.0800 (-0.84)	-0.0044** (-2.32)		0.0204** (5.09)	0.0763** (4.03)	0.305	22.55**
4	-0.6065** (-5.43)	-0.0034* (-1.79)	0.0363** (8.70)	0.0229** (5.75)	0.0507** (2.67)	0.317	60.82**
Panel D. Random effects model							
1	0.0041 (1.02)	-0.0027 (-1.38)			-0.0041 (-0.71)		
2	-0.0936** (-4.93)	-0.0015 (-0.76)	0.0066** (5.27)		0.0069 (1.12)		
3	0.0133** (2.84)	-0.0032 (-1.61)		0.0098** (3.91)	-0.0036 (-0.62)		
4	-0.1106** (-5.77)	-0.0018 (-0.91)	0.0086** (6.67)	0.0148** (5.66)	0.0112* (1.80)		

Notes: This table reports the coefficients on the panel regressions. In each month from January 2000 to December 2012, panel regressions are used to estimate Equations (5.1) to (5.4). The associated *t* statistics are reported in parentheses under the relevant coefficients. * $p < 0.10$, ** $p < 0.05$.

The results of the non-US water stocks display a similar pattern, except that the asset liquidity factor is not consistent in predicting water stock returns when water firms from several parts of world are regressed together using firm and time fixed effects model (Panel C, Table 5.6). A possible explanation is that the asset liquidity factor is not a universal risk proxy, and thus their validity is limited to

certain corporate governance settings (Organisation for Economic Co-operation and Development, 2009).

Table 5.6 Coefficient Estimates from Panel Regressions of Average Monthly Return on Beta, Ln(Size), Ln(BE/ME), and Asset Liquidity (World Water Stocks Exclude US)

Model	Intercept	Beta	Ln(Size)	Ln(BE/ME)	Asset Liquidity	Adj. R ²	Chi-Sq.
Panel A. Ordinary least square regression							
1	-0.0011 (-0.26)	-0.0016 (-0.70)			0.0027 (0.36)	0.000	
2	-0.0312** (-2.28)	-0.0025 (-1.09)	0.0024** (2.32)		0.0041 (0.54)	0.001	
3	0.0056 (1.20)	-0.0013 (-0.58)		0.0107** (4.02)	0.0032 (0.42)	0.003	
4	-0.0241* (-1.75)	-0.0022 (-0.97)	0.0023** (2.29)	0.0107** (4.00)	0.0045 (0.60)	0.004	
Panel B. Firm fixed effects model							
1	-0.0005 (-0.04)	-0.0027 (-1.06)			0.0153 (1.22)	0.000	2.02
2	-0.2716** (-6.98)	-0.0040 (-1.59)	0.0196** (7.38)		0.0206* (1.65)	0.009	51.83**
3	0.000 (0.00)	-0.0022 (-0.88)		0.0247** (6.82)	0.0253** (2.02)	0.008	34.10**
4	-0.3205** (-8.21)	-0.0036 (-1.46)	0.0232** (8.67)	0.0298** (8.20)	0.0336** (2.69)	0.025	105.94**
Panel C. Firm and time fixed effects model							
1	0.0501 (1.15)	-0.0041* (-1.63)			0.0076 (0.61)	0.154	5.20**
2	-0.2801** (-4.73)	-0.0062** (-2.49)	0.0244** (8.17)		-0.0038 (-0.30)	0.168	68.52**
3	0.0450 (1.03)	-0.0037 (-1.49)		0.0172** (4.46)	0.0181 (1.42)	0.158	11.06**
4	-0.2947** (-4.99)	-0.0059** (-2.36)	0.0251** (8.40)	0.0187** (4.88)	0.0073 (0.58)	0.173	78.98**
Panel D. Random effects model							
1	-0.0011 (-0.26)	-0.0016 (-0.70)			0.0027 (0.36)		
2	-0.0312** (-2.28)	-0.0025 (-1.09)	0.0024** (2.32)		0.0041 (0.54)		
3	0.0056 (1.20)	-0.0013 (-0.58)		0.0107** (4.02)	0.0032 (0.42)		
4	-0.0241* (-1.75)	-0.0022 (-0.97)	0.0233** (2.29)	0.0107** (4.00)	0.0045 (0.60)		

Notes: This table reports the coefficients on the panel regressions. In each month from January 2000 to December 2012, panel regressions are used to estimate Equations (5.1) to (5.4). The associated *t* statistics are reported in parentheses under the relevant coefficients. * *p* < 0.10, ** *p* < 0.05.

Since the risk of investment irreversibility is affected by industry characteristics (Zhang, 2005), it is reasonable to expect varying relationships

between asset irreversibility and return across different industries (Docherty et al., 2011). After controlling for industry representation, Docherty et al. (2011) find that the existence of their investment irreversibility factor is limited to the materials industry only. They argue that this is because the materials industry is characterised by a high proportion of irreversible assets, and that the investment irreversibility effect may not be applicable to other business sectors. Docherty et al. (2011) further explain that they do not analyse utility industries due to small sample size. Our study extends their observation to the water industry and suggests that the asset liquidity effect we find in the present study should be attributed to the high proportion of illiquid assets. We thus conclude that the asset liquidity factor may be a special industry factor that needs to be considered when investing in the water industry.

To summarise, our study establishes that asset illiquidity is a risk factor for the water industry. It provides empirical support for the investment irreversibility theory put forward by Cooper (2006) and Docherty et al. (2010, 2011). However, our results cannot be fully explained by Docherty et al. (2010)'s theory that the value premium (book-to-market effect) is derived from the risk of investing in irreversible assets-in-place. Asset liquidity seems to be a relevant pricing factor, but the reasons underlying the asset liquidity effect remains unclear.

Besides the asset liquidity factor, we find that the coefficients of the size variable remain positive in all regressions. The results are contrary to the prior evidence indicating a negative relationship between the size factor and stock return (Fama & French, 1992). A possible explanation is that in the previous studies, the negative size effect is most prevalent in microcap stocks (Fama and French, 1992; Brailsford et al., 2012). The water industry, on the other hand, has very few microcap firms but an average market capitalisation that is substantially greater than other industries. The high concentration of large firms may explain why the size factor has a positive sign in this study, and not the opposite. Another possibility is related to the existence of economies of scale in the water industry. There is a positive relationship between size and efficiency in water businesses (Fraquelli and Giandrone, 2003), as the efficiency of water companies can be greatly improved through investment diversification or vertical integration strategy within the value chain of water industry.

Our argument is partly supported by Hsieh and Hodnett (2012), who find that exposures to the size premium are inconsistent in the context of global equity sectors. While most sectors do have a negative size effect, the capital intensive sectors such as basic materials sector, oil and gas sector, industrials sector, and utilities sector exhibit positive exposures to the size risk premium. Reasons behind

the positive size effect remain elusive, but it is important for investors to be aware that larger firms tend to receive a premium over smaller firms in the water industry.

5.6. Conclusions

The water industry is characterised with a high proportion of fixed and irreversible investments, resulting in considerable asset in place risks. Using the asset liquidity ratio as a proxy for irreversibility, we address the question of whether there is a relationship between this asset in place risk and stock return in panel data frameworks. Employing the fixed effects model, we find that asset liquidity is a significant determinant of return variations in water companies across the world, and so are the size factor and book-to-market ratio. We find that water firms with a larger proportion of illiquid assets-in-place demand higher stock returns than firms with a smaller proportion of illiquid assets. Our results support the notion that the irreversibility or illiquidity of assets-in-place produces a distinct effect in explaining water stock returns. Moreover, we find that the magnitude and significance of the relation between asset liquidity and stock return is not reduced by the presence of control variables. It means that the asset liquidity effect is not related to variables such as book-to-market ratio, which is contrary to our expectation that asset liquidity serves as a driving force behind the value premium. Instead, we believe that the asset liquidity factor captures additional information about water stock return that is not represented by the other variables, though the underlying mechanism is yet to be

clarified. Future research needs to clarify whether the asset liquidity factor is an industry factor or a variable concerning all stocks. Gopalan, Kadan, and Pevzner (2012) point out that asset liquidity is associated with stock liquidity. Coupled with the well-recognised relationship between stock liquidity and return, asset liquidity may affect return indirectly through stock liquidity.

These results have important implications for the management of water resources. Currently, the global water industry is in need of huge amounts of investments if the severe shortage of water is to be addressed. Given the governments' financial constraints, private sector participation is urgently required in order to obtain the much desired financial resources for building and upgrading water infrastructures, environmental protection and providing safe and sanitary water to areas suffering from severe water distress. If investors are to get involved, they would need to understand the returns and risks that are associated with investments in the water industry. A major risk that is inherent in this industry, by virtue of its being heavily infrastructure-based, is the so-called "illiquidity risk". It has been shown in this study that illiquidity risk indeed is a risk that is priced or compensated in terms of extra returns in relation to the water industry. If governments are to go into partnership with private sector investors, they must recognise that these investors do expect to be compensated for the illiquidity risk, in addition to other risks, that exist within the water industry.

Chapter 6 Regulation and Systematic Risk in the Water Industry:

Evidence in the Context of China⁴

As discussed in the previous chapters, the water industry faces not only asset illiquidity risk but also regulatory risk. The presence of regulatory risk is a worldwide phenomenon that affects most industries (Beaulieu, Cosset, & Essaddam, 2005). This is because politics and economics are intertwined and inseparable (Nordhaus, 1975; Hibbs, 1977). Regulatory risk is defined as a risk to a firm's profitability as a result of an external force involving government action or, occasionally, inaction (Wells, 1998). Common forms of regulatory risks include the uncertainty related to attitude of consumers, investors and the government (Madura, 2000). Specifically, regulatory risks faced by a commercial water operator are usually due to governmental interference on breach of control, barrier to entry, water pricing and quality control. Regulatory risks can be reduced by good policymaking such as transparency in the awarding of contracts and in operational decisions (Lobina & Hall, 2003). However, it is almost unavoidable that, even in mature water economies, unexpected actions by regulators can create risks for operators, their shareholders and financiers (United Nations Environment Programme Finance Initiative, 2006). The political uncertainty associated with water investments lead to

⁴ This chapter includes a paper that is currently under review: Jin, Y., Roca, E., Li, B., & Wong, V. (Under Review). Regulation and Systematic Risk in the Water Industry: Evidence in the Context of China, *Journal of Regulatory Economics*. Statement of Contribution as a co-author can be found in pages x-xv.

investors demanding high returns and very cautious in their decision making. Moreover, the economic lives of major water assets are usually 70 to 90 years, while regulatory cycles are typically 3 to 5 years. The huge discrepancy between asset lifetimes and the span of regulatory cycles is considered to be a key deterrent of private water investments (Ergas et al., 2001).

Regulatory risks can be measured through political risk ratings distributed by leading international banks and commercial agencies (Bilson, Brailsford, & Hooper, 2002), or through the examination of market/stock moves on the dates of the political events (Buckland & Fraser, 2001). The second approach which assesses regulatory intervention risk is more appropriate for research on sector-specific regulatory risk, because it has the ability to identify the impact of each regulatory announcement on the systematic risk. Therefore, the present study investigates water industry's regulatory risk by examining the impact of regulatory interventions on firms' time-varying systematic risks.

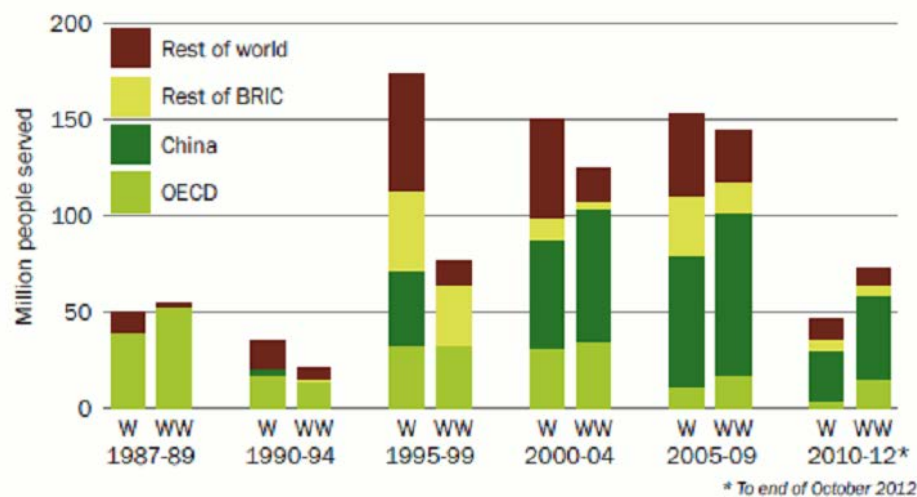
The study uses the Chinese water market as a proxy to understand the regulatory effect on the riskiness of water businesses. China's water market is chosen for three reasons: Firstly, the emerging countries have great needs for funds to build/update necessary water infrastructure and to preserve environment. As a developing country, China has almost 20% of world's population and only about 6%

of global freshwater resources. Urbanisation and rising environmental awareness is driving rapid growth in urban water supply and wastewater market, causing further water distress. However, investors, in effect, are more willing to invest in developed water markets due to their low political risks compared to emerging markets. Prequin (2011) reports that 47% of investors target European assets, while 36% focus on North American infrastructure. Therefore, it is crucial for both water investors and policy makers to fully understand the impact of regulatory changes. Despite the need for knowledge, little empirical research has been done in this area. For the few existing studies, researchers predominantly focused on the British water market. To date, investment characteristics of the water industries in the emerging world are largely unknown.

Secondly, China's water market is not only one of the three largest water markets in the world, but also the largest market in terms of the number of people served by the private water sector (Pinsent Masons, 2009) (See Figure 6.1). It is estimated to be worth EUR 60 to EUR 100 billion a year over the next ten years (European Small and Medium-sized Enterprises Centre (EU SME), 2013) (See Figures 6.2). The majority of the companies competing in the market are local companies. Foreign companies provide about 8% of the total national water supply. Nevertheless, despite the prosperity of the water industry, China faces many challenges in its water efficiency, water technologies and funding (Dore, Peiyuan,

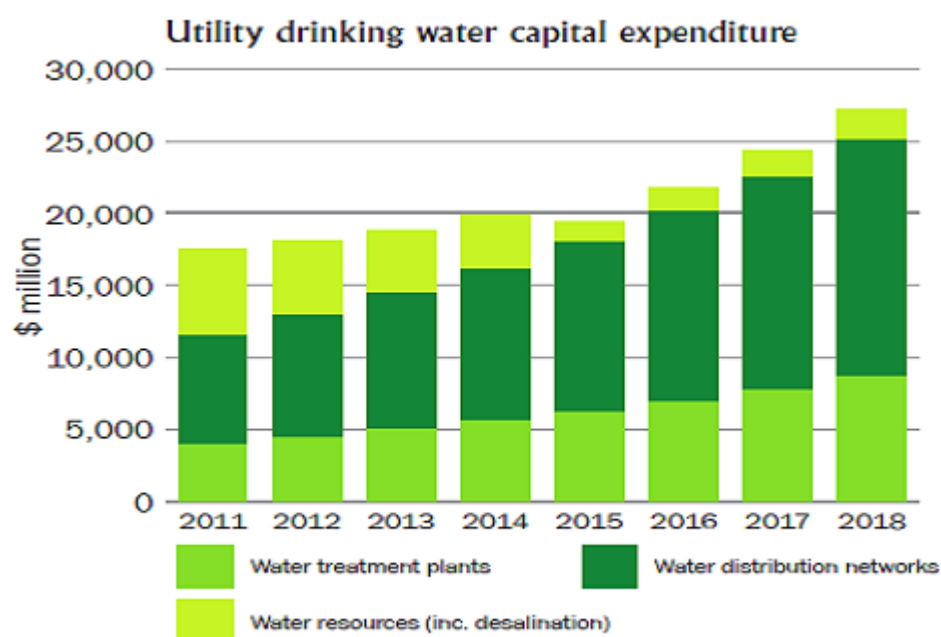
Nette, & An, 2010). The absolute size of China's water market and the diversity of opportunities available have made it a global and regional driver, as well as a good subject for regulatory risk research.

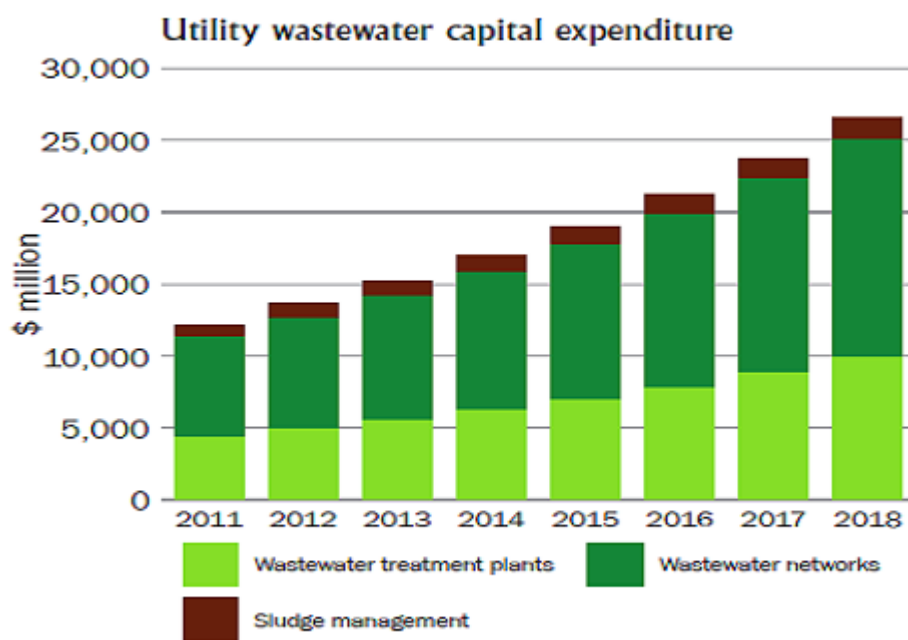
Figure 6. 1 Number of People Served by New Water and Wastewater Contracts in Different Regions of the World



Source: Global Water Intelligence, 2012 (cited in EU SME, 2013)

Figure 6.2 National Urban Water Supply and Wastewater Capital Expenditure 2011 to 2018 Forecast





Source: Global Water Intelligence (cited in EU SME, 2013)

Thirdly, water industry, in general, is highly fragmented and diverse. Like the industry itself, water regulation is also fragmented. The Chinese government has placed a great emphasis on addressing its dramatic domestic water needs, and hence the government has announced a series of regulatory decisions regarding the water industry in the past decade. Unlike the other countries where uniform regulations are lacking, China has a central regulation agency whose policies can affect the whole nation, resulting in a methodological advantage for empirical research.

This study aims to explore how water investors incorporate regulatory risk in equities prices in China. An empirical verification of regulatory risk can contribute to our understanding of water investors' strategies and water regulators' policy

making. It helps attract additional funds to this economically relevant, yet underfunded industry. The results are, to some extent, generalisable to other water markets.

6.1. Introduction

Over the last twenty years, a wave of privatization has taken place around the world and has greatly transformed the water industry. The ongoing privatization trend has converted an increasing number of formerly state-owned water companies into private and joint stock companies through selling water assets to the private sector. A key notion underlying the privatization of water sector is the belief that water is an economic good (Savenije, 2002).

However, it is more complex than that. Water bears an intimate relationship to public health and the environment. Freshwater in its natural setting is non-rivalry and non-excludable, and having access to it at an affordable price is the right of all human beings. The innate nature of water makes it a conventional public good (Schouten & Schwartz, 2006). Moreover, water industry is in a position of natural monopoly. Water is the most capital intensive utility and is facing a demand with very low price elasticity. Most consumers have no choice on the quality of the water consumed or the services provided. These characteristics confront water industry to a typical instance of market failure which unavoidably leads to the intervention of

various regulations from governments and public agencies (Pescetto, 2008). Water regulations are designed to balance the interests of investors and consumers and to serve a broader public interest. It is widely documented that regulations play an important role in the success or failure of water industry privatization (Jamash, Mota, Newbery, & Pollitt, 2005).

Regulations of the water sector deal with various aspects (e.g., price, quality of services, rules for investment, and entry requirement) and affect all stakeholders. As emphasized by Schouten and Schwartz (2006), investing in a public good such as water is not only a question of calculating the economic cost-benefit ratio, but understanding how it is intertwined with a regulatory realm. Regulatory risk is considered as a determinant of the performance of water industry; investors need to appreciate the impact of regulatory systems on their cost of capital, economic viability of investment projects, and prices and yields of their shares (United Nations Environment Programme Finance Initiative, 2006).

Despite the growing interest and need for knowledge of regulatory risk in relation to the water market, little empirical research has been done. To date, investment characteristics of the water industries in the emerging world are largely unknown. To address this imbalance and further contribute to the literature, we provide a detailed study of the impact of regulatory announcements on the Chinese

water market. These regulations are related to issues including competition, price, and service quality. We choose the Chinese water market as it is not only one of the three largest water markets in the world, but also the largest market in terms of the number of people served by the private water sector (Pinsent Masons, 2009). China has placed a great emphasis on addressing its dramatic domestic water needs, and hence the government has announced a series of regulatory decisions regarding the water industry in the past decade. Unlike the other countries where uniform regulations are lacking, China has a central regulation agency whose policies can affect the whole nation, resulting in a methodological advantage for empirical research. We believe our study of how water investors incorporate regulatory risk in equities prices in China can be used as a proxy for other water markets. Furthermore, an empirical verification of regulatory risk can contribute to our understanding of water investors' strategies and water regulators' policy making. It helps attract additional funds to this economically relevant, yet under-funded industry.

Our paper aims to explore the riskiness of water businesses in the context of dynamic privatization processes. In the 1990s many countries have witnessed rapid privatization of their water sectors. This rapid change has led to a few empirical investigations focusing on the U.K's water industry during the 1990s (Buckland & Fraser, 2001; Pescetto, 2008). However, the global privatization trend appears to have slowed down after the turn of the century (China's water privatization has, in

fact, speeded up in the new century) and research in this field came to a halt. There is a clear gap in the water literature looking at the systematic risk of water industry in the 21st century and more so, in the developing countries. Our study contributes to the literature by updating our understanding of water industry's systematic risk and the effect of regulatory changes. Compared with the U.K. where there is one single mature central water authority, China's fragmented yet centralized water management system carries more similarities with the rest of the world, making the study results more generalizable.

Our empirical analysis is composed of two parts. First, using the Kalman Filter procedure, we estimate the time varying systematic risk of water companies based on the Capital Asset Pricing Model (CAPM). Our sample consists of 19 companies operating in China's water and wastewater industry. We then analyze the industry's regulatory risk by regressing the calculated betas on different types of regulation announcement events. These announcements are classified into five groups according to their potential impact on market competition, water prices, and quality of water services. We find that regulatory announcements that are expected to reduce market competition, increase water prices, and improve quality of water services have significant impacts on the systematic risk of China's water industry with and without controlling for accounting variables. Moreover, how these regulatory changes affect the systematic risk may be dependent on investors'

interpretation of a larger political environment. We then examine the effect of regulatory changes on individual water companies' systematic risks and find that most water companies are not significantly affected by these changes. The results further reveal that regulatory changes that have a significant impact at the industry level may not have the same effect at an individual company level. Lastly, we assess the overall effect of regulatory announcements on the industry's systematic risk. The results suggest that an official announcement released by a regulator has no significant impact on the industry's systematic risk. There is no evidence supporting an overall regulatory intervention risk for the water industry.

The paper is organized as follows. Section 6.2 reviews the characteristics of the Chinese water industry and recent developments in regulatory policy making. Section 6.3 discusses the relationship between regulation and systematic risk of regulated industries and firms. Section 6.4 details our research method and data, followed by Section 6.5 which presents the results and empirical findings. Finally, Section 6.6 concludes with the implications of our study and possible directions for future research.

6.2. The Regulation of China's Water Industry

Traditionally, the central role of the water industry to the protection and preservation of public health has encouraged the Chinese government to manage its

water industry within the public sector (MacGillivray, Hamilton, Strutt, & Pollard, 2006). In the late 1990s, using borrowed experience from the U.K. and other European countries, the government started to pursue a massive program of privatization of water utilities in the hope of improving systematic efficiency and attracting private funds. Although private participation in water and wastewater services in China was legislated by various laws in as early as the 1980s, the government did not formally open its national urban utility market to domestic private players until 2002-03. To date, China's private investors have managed to explore the water market using three approaches: 1) working in joint ventures with international companies, 2) working through a dedicated infrastructure fund, and 3) setting up Chinese owned private companies (Pinsent Masons, 2004). Among those, the third approach has been used most widely. It is typically carried out by converting public water companies into joint stock companies and selling their equities to the private sector through public offerings on the Shanghai and Shenzhen Stock Exchanges. Returns on these private investments are thus reflected in the behavior of the prices and yields of their shares as quoted on the exchanges.

The landscape of China's water market has undergone an enormous change since the beginning of privatization. Till the end of 1999, nearly 30 million people were served by the private sector in various forms. This number has been growing dramatically, and it is believed that contracts covering around 300 million people

have been awarded to private water and wastewater companies in China by 2012. (European Small and Medium-sized Enterprises Centre (EU SME), 2013). These private water companies serve consumers by providing various products and services such as collecting, treating, conveyancing, and monitoring/analyzing water and wastewater. Currently, China is not only the world's largest water market in terms of the number of people served by private sector, but also the most dynamic market in terms of the rapidity of its development (Pinsent Masons, 2007). The absolute size of China's water market and the diversity of opportunities available have made it a global and regional driver, as well as a good subject for regulatory risk research.

However, it is worth pointing out that the transfer of ownership in privatization does not alter the public goods nature of the water industry. Moreover, due to the peculiar characteristics of water privatization, it is exposed to all of the traditional instances of market failure, for instance, natural monopoly conditions, negative externalities, and capital intensity (Pescetto, 2008). Therefore, regulatory arrangements have to be set up to improve the quality of services, to protect consumers against monopolistic exploitation as well as to reduce environmental cost. According to EU SME (2013), the Chinese government has been encouraging funds necessary for water infrastructure investments and incentivizing consumers towards more efficient uses of water by introducing aggressive water pricing mechanisms.

This process is consistent with the government's needs of both economic transformation and water service improvement in a country that suffers from severe water shortages (Pinsent Masons, 2004).

China's water regulatory landscape ranges from controlling and preventing water pollution to mandating pricing and funding policies of water services. Similar to their overseas counterparts, the Chinese water companies are subject to a variety of regulatory jurisdictions (Beecher, 2009). However, differing from developed countries, China has a number of authorities involved in water governance at the central government level. In general, the State Council, the Ministry of Development and Reform Commission, and the Ministry of Finance take charge of regulatory schemes of water pricing and water funding, while the Ministry of Water Resources, the Ministry of Environmental Protection, and the Ministry of Housing, Urban and Rural Construction share the responsibility for managing water quality, water quantity, and environmental regulations (EU SME, 2013). For the purpose of our research, we only examine the impact of changes in central regulations, for all local regulators are required to follow the same overarching core principles and general practices set by Beijing.

6.3. The Relationship between Regulatory Changes and Systematic Risk

As China's water industry was historically under the control of public sector, the regulations were mostly self-imposed and limited in scope. Traditional state-owned water companies were barely affected by regulatory risk. However, the recent (since 2002) water privatization movement has externalized and broadened the role of regulatory scrutiny and intervention, and thus making regulatory risk one of the greatest strategic challenges/threats to the businesses on the Chinese water market (Dore, Peiyuan, Nette, & An, 2010). The significant impact of regulatory risk on water industry is, of course, not unique to the Chinese water businesses (Buckland, Williams, & Beecher, 2015; MacGillivray et al., 2006; Pescetto, 2008). Therefore, the results from our study may also be informative to stakeholders in the global water market.

Regulatory risk on China's water market can be caused by expected and unexpected announcements from the central regulators. It is the result of the uncertainty behind new and changing regulations over time (Ernst & Young, 2008). These regulations usually aim to influence strategic decisions of individual water companies. For example, regulations on environmental protection, price control, investor protection, and market entry restrictions are all intended to facilitate the transfer of wealth and social responsibilities between stakeholders either as an end in its own right or as a means to achieve specific objectives. In contrast, very few

regulatory changes that apply to water companies aim primarily to transfer risks between parties, and hence few regulatory changes enable the risk effect to be isolated for empirical investigation (Grout & Zalewska, 2006). As a result, despite the vast literature on water regulation, no equivalent efforts have been made to address the riskiness of these regulations. In other words, the strand of literature that explicitly shows how investment risk of the regulated firms responds to water regulatory changes is small. Therefore, the question of the utmost importance here is whether regulatory decisions affect systematic risk of water companies traded on the Chinese stock market. An answer to this question would not only appeal to researchers but interest policy makers. As systematic risk cannot be diversified away, regulators should compensate shareholders for bearing such risk (Paleari & Redondi, 2005).

There has been a multitude of debates, in both theoretical and empirical literature, on how regulation affects risk in a public utility industry. Peltzman (1976) provides important contributions to the understanding of the relationship between regulation and risk by proposing the ‘buffering effect’. He argues that companies operating in competitive markets face more volatile profits that occur due to such factors as stranded costs, classic externalities, and increased demand volatilities. Comparatively, regulated companies often get maximum political support from regulators, which buffers the abnormal profits between shareholders and customers.

A similar argument often made for the water industry is that because continuity of service is so important, regulators do not want regulated water companies to become bankrupt (Grayburn, Hern, & Lay, 2002). In fact, in spite of privatization, water provision is still subsidized by governments in order to ensure its universal availability in urban areas. Therefore, according to Peltzman's theory, water regulations tend to buffer downside returns and alleviate the investment risk on water companies.

The buffering effect theory is widely investigated empirically since its proposition. Most studies on infrastructure industries are supportive of its predication that price regulation buffers cash flows and reduces market risk. Employing the same sample of U.S. electric utility companies, both Norton (1985) and Binder and Norton (1999) find supporting evidence for the buffering effect theory. Fraser and Kannan (1990) adopt a larger and more diverse sample of U.S. infrastructure and financial firms and conclude that systematic risk of firms under rate regulation is uniformly lower than for their unregulated peers. Alexander, Mayer, and Weeds (1996) extend the regulatory risk analysis to the global utility industry sectors. They find asset betas are positively related to the degree of efficiency incentives, lending support to Peltzman's buffering theory. In follow-up studies, both Alexander, Estache, and Oliveri (2000) and Grout and Zalewska (2006)

corroborate the finding that non-U.S. companies with high-powered regulation have higher betas than those with other regulatory regimes.

However, whilst the traditional view is that the buffering effect of regulation reduces the systematic risk to which a regulated utility is exposed, recent literature finds factors such as information asymmetry, regulation inconsistency, and regulatory lag of imperfect regulation mechanisms can actually increase the cost of capital for regulated utilities and therefore enhance their systematic risk (Grayburn et al., 2002). The universal validity of the buffering hypothesis is questioned empirically, too. Davidson, Rangan, and Rosenstein (1997) partially reject Peltzman's buffering hypothesis in their examination of U.S. electric utility industry. They fail to detect lower systematic risk for intensely regulated firms during periods of falling or relatively stable factor prices. Gaggero (2012) challenges Alexander et al.'s (1996, 2000) conclusion by analyzing the impact of regulatory regime on market risk for regulated companies in 200 countries. In contrast to the previous research, he finds no significant difference between low and high incentive schemes for various model specifications. Moreover, in the only study investigating an emerging market, Barcelos (2010) samples 67 Brazilian companies (electricity, telecommunication, commodities, domestic sectors) and find that equity betas of regulated firms are not different from (or even higher than) those of their unregulated peers when controlling for the time-varying nature of betas as well as

equity and time-specific factors. When further analyzing the reaction of firms' market risk to specific regulatory changes, he finds evidence suggesting that the additional regulations do not reduce, but rather increase the regulated firms' betas, directly contradicting the buffering hypothesis.

Instead of comparing the systematic risks between regulated and unregulated firms, some researchers have analyzed the time-series policy changes and their impact on firm risk. This approach has two advantages: a) the same firms can be observed over time; and b) potential biases from other risk factors are minimized (Rothballer, 2012). Thus far, the few studies that adopt this approach have yielded mixed results. There has been evidence from industries such as water, natural gas, and telecommunication suggesting the existence of the buffering effect across different countries (Buckland & Fraser, 2001; Chen & Sanger, 1985; Sidak & Ingraham, 2003). However, the disputing evidence has been equally strong. Nwaeze (2000) analyzes three major policy changes in the U.S. electric utility industry and finds a significant increase in earnings variability, systematic risk as well as negative abnormal returns around the events. The results indicate a reversal of the buffering effect. Paleari and Redondi (2005) explore the U.K. electricity distribution industry and find that as regulation gets stricter, companies' systematic risk will increase, and vice versa. Moreover, Antoniou and Pescetto (1997) and Pescetto (2008) conclude that while some regulations tend to affect their industry as a whole, others have a

diverse impact on individual companies. This implies that regulation itself may be only a source of uncertainty, rather than an impacting factor on the systematic beta risk with a specific direction. The literature remains unclear as to the existence of regulation effect on systematic risk.

Compared with the other infrastructure industries, water businesses are largely overlooked by researchers. For the few studies that examine the impact of regulatory changes on water firms, their focus has been placed on the British water market possibly because of its long history of water privatization and the existence of a central government body – the Office of Water Services. To the best of our knowledge, there has been no empirical investigation of emerging countries' water issues. Moreover, the lack of uniform verification of regulation effect in the current literature has made it especially difficult for stakeholders to capture the risk associated with changing water regulations. Our paper aims to explore this untouched area and to improve our understanding of the links between regulation and the risks faced by regulated water firms.

6.4. Methodology and Data

In general, two approaches can be distinguished in the research of regulatory risk. The first approach is done by testing 'regulatory system risk' – the risk related to the form of regulation. Such studies look at betas across sectors and compare the

effects of different regulation regimes. The second approach assesses ‘regulatory intervention risk’ – the risk associated with a particular event or action taken by a regulator. These studies examine the impact of regulation announcements on firms’ time-varying betas (Grayburn et al., 2002). Our paper follows the methods of Buckland and Fraser (2001) and Pescetto (2008) and combines these two approaches by classifying and measuring the impact of regulatory interventions on the systematic risks of the same group of companies over a period of time.

A two-step procedure is used to verify whether regulatory risk exists in China’s water industry. In the first step, we estimate the systematic risk of water companies based on the CAPM. The CAPM is used here not only for its academic attractions (it has been widely used to estimate the impact of regulatory risk of regulated utilities), but also due to its consistency with the modeling approach of regulators and water companies in most countries (Alexander et al., 1996; Buckland & Fraser, 2001). Assuming a fixed risk-return relationship, we have the following expression:

$$R_{it} = R_{ft} + \beta_i(R_{mt} - R_{ft}) + \varepsilon_{it} \quad (6.1)$$

where R_{it} is the continuously compounded return from a risky asset i ; R_{ft} is the continuously compounded return from a risk-free asset; β_i is the measure of the systematic risk of asset i ; ε_{it} is a random error term.

It is, however, a stylized fact of empirical finance that betas are not stable over time (Antoniou & Pescetto, 1997; Buckland & Fraser, 2001; Grout & Zalewska, 2006; Paleari & Redondi, 2005). Considering the uncertainty surrounding the privatization of water industry, the changes in the political and economic environments in China, and particularly, the development of quality, health, and environmental issues relating to the supply of water and sewage services during the sample period, a model that assumes constant systematic risk and does not capture the dynamic behavior of asset returns would be inappropriate. Instead, for the purpose of analyzing the sensitivity of betas to regulatory factors, we transfer Equation (6.1) to Equation (6.2):

$$r_{it} = \alpha + \beta_t(r_{mt}) + \psi_{it} \quad (6.2)$$

where r denotes respective excess returns; β_t denotes a time-varying beta; ψ_{it} is a random error term. Our aim is to extract from Equation (6.2) a time series of betas for each of the water companies in our sample.

Following Buckland and Fraser (2001) and Paleari and Redondi (2005)'s method, we employ the Kalman Filter procedure for the maximum likelihood estimation of beta. The Kalman Filter procedure utilizes a state-space model to extract and incorporate information from the conditional variance of prior returns in modeling the evolution of model parameters. It is a dynamic and recursive algorithm. It allows time-varying parameters to be stochastic and uses all available information

in estimation. We allow the time-variation of the betas to follow the process that is described as follows:

$$r_{it} = \beta_{i,t}(r_{mt}) + \mu_{it} \quad (6.3)$$

$$\beta_{i,t} = \beta_{i,t-1} + v_{i,t} \quad (6.4)$$

where β is an AR(1) process; μ_{it} and v_t are independent white noise error terms. Equation (6.3) is now termed as the measurement equation. Equation (4) is the state equation describing the time-varying behavior of the parameter β_t .

In the second step, further tests for the impact of regulatory intervention risk on China's water companies are conducted by regressing betas on different types of regulation announcement events. As mentioned above, water industry in China is mainly influenced by regulations coming from the six regulatory bodies at the central government level. In line with Pescetto (2008), we group all the water-related regulation announcements made by these regulators based on their expected impact on competition, prices, and quality of services. Specifically, there are five types of regulatory announcements that are expected to cause increased competition ($COMP^+$) within the industry, decreased competition ($COMP^-$) within the industry, increased water prices ($PRICE^+$), decreased water prices ($PRICE^-$), and increased quality of services ($QUAL^+$). The equation estimated is as follows:

$$\beta_{it} = \gamma_0 + \gamma_1 COMP^+_t + \gamma_2 COMP^-_t + \gamma_3 PRICE^+_t + \gamma_4 PRICE^-_t + \gamma_5 QUAL^+_t + e_{it} \quad (6.5)$$

where β_{it} is the time-variant systematic risk of the water industry portfolio; $COMP^+_t$, $COMP^-_t$, $PRICE^+_t$, $PRICE^-_t$, and $QUAL^+_t$ are dummy variables equal to one during the week of each regulatory announcement and zero otherwise; e_{it} is a random error term. The parameters $\gamma_1, \dots, \gamma_5$ detect changes in water industry's systematic risk as a result of particular types of regulatory announcements. Panel data analysis, to be specific, a (firm) fixed effects model is used. This model assumes that each firm has its own individual characteristics which may influence the independent variables. The fixed effects regression controls the effects of those time-invariant characteristics, and thus the estimated coefficients cannot be biased.

Using Equation (6.5), the following hypotheses about the effects of each group of announcements on the water industry's systematic risk are tested:

- i. announcements that are expected to increase (decrease) competition are also expected to increase (decrease) β ($\gamma_1 > 0$, $\gamma_2 < 0$);
- ii. announcements that are expected to increase (decrease) the price of services are also expected to decrease (increase) β ($\gamma_3 < 0$, $\gamma_4 > 0$);
- iii. announcements that are expected to increase quality threshold of services are expected to increase β ($\gamma_5 > 0$).

Pescetto's (2008) approach attributes any resulting differences in the systematic risk to regulatory announcements. However, Alexander et al. (1996) argue that the observed variation on water companies' betas can be a result of other

factors that may or may not be relevant to regulatory announcements. Hence, it is necessary to control the effects of these alternative factors so that we can identify the real impact of regulation on systematic risk (Chalmeau, 2013). The existing literature has established strong links between CAPM beta and accounting variables (Beaver, Kettler, & Scholes, 1970; Logue & Merville, 1972). Therefore, we develop Equation (6.6) based on Equation (6.5) and evaluate the effect of regulation announcement events on the systematic risk of the water industry while controlling for the main financial determinants including financial leverage (ratio of total debts to current assets), operating efficiency (ratio of revenue to total assets), profitability (ratio of net incomes to assets), liquidity (quick ratio), and firm size (natural logarithm of total assets) (Chalmeau, 2013). The system of equations estimated is as follows:

$$\begin{aligned} \beta_{it} = & \gamma_0 + \gamma_1 COMP^+_t + \gamma_2 COMP^-_t + \gamma_3 PRICE^+_t + \gamma_4 PRICE^-_t + \gamma_5 QUAL^+_t \\ & + \gamma_6 C_{it} + e_{it} \end{aligned} \quad (6.6)$$

Equation (6.6) shares the same variables as Equation (6.5) except for variable C_{it} which is a vector of firm-level controls. The parameter γ_6 detects changes in water companies' systematic risk due to their financial positions.

The Chinese water administrative systems are complex and suffer from fragmentation across ministries. According to Organisation for Economic Co-operation and Development (OECD) (2009), the central and local governments can

have different and sometimes conflicting goals. The sampled water firms are based in different provinces in China and are therefore governed by varying local water authorities. Given that the firms operate in diverging regulatory environments, it is important to examine whether the five types of announcement events have the same impact on the industry.

Therefore, in addition to the fixed effect panel regression analysis, the following regression is estimated (Pescetto, 2008):

$$\begin{aligned} \beta_{it} = & \eta_0 + \eta_1 COMP^+_t + \eta_2 COMP^-_t + \eta_3 PRICE^+_t + \eta_4 PRICE^-_t + \eta_5 QUAL^+_t \\ & + \eta_6 C_{it} + \kappa_{it} \end{aligned} \quad (6.7)$$

where β_{it} is the systematic risk of company i in year t ; the parameters η_1, \dots, η_5 detect changes in each company's systematic risk due to particular types of regulatory announcements; η_6 is the coefficient of controlled variables; κ_{it} is a random error term. The regulatory announcement variables and controlled accounting variables are defined as above. We use pooled Ordinary Least Squares regression to evaluate the impact of the announcement events on individual water company's systematic risk over the sample period.

In the final step, we investigate the overall effect of regulatory changes on the industry's systematic risk and examine whether the buffering effect of regulation applies to the Chinese water industry. Instead of sorting the regulatory

announcements into five groups of regulatory intervention events, we create a new dummy variable. When at least one regulatory event is made in a particular week, the dummy variable is considered to be one, and zero otherwise. Equation (6.8) below measures the overall impact of regulation on the systematic risk of the whole industry.

$$\beta_{it} = \chi_0 + \chi_1 ANNO_t + \chi_2 C_{it} + \theta_{it} \quad (6.8)$$

where β_{it} is the systematic risk of the water industry; $ANNO_t$ indicates the occurrence of a regulatory announcement; C_{it} represents the controlled accounting variables; θ_{it} is a random error term. This regression investigates the joint explanatory power of all kinds of regulatory announcements on the systematic risk of China's water industry. If regulatory change is a risk factor, the coefficient of the regulatory announcement variable should be significant after controlling for the accounting variables.

Our study sample consists of 19 Chinese water companies (see Appendix 6.1) that trade publicly on the Shanghai and Shenzhen Stock Exchanges. These companies provide direct water and sewage services to customers, and these services constitute their main source of revenue. As most of the water companies are conglomerates covering multiple segments of the water industry such as utilities, infrastructure, sewage, and water treatment, our sample serves as a good benchmark of China's water market.

We obtain panel data for all the 19 firms from DataStream covering the period from January 1, 2002 to December 31, 2013 (12-year period). We choose to use this sample period as China's water market was, in fact, not open to the private sector until 2002. Our sample contains weekly stock prices and various financial data on balance sheets. We use the MSCI China Index and the one-month China Interbank Offered Rate as estimates of market return and risk free return, respectively. Any official news directly relating to regulatory changes in China's water industry is considered as regulatory announcements (see Appendix 6.2 for distribution of announcements and Appendix 6.3 for representative samples). The six publishing regulatory bodies in China include State Council, the Ministry of Development and Reform Commission, the Ministry of Finance, Ministry of Water Resources, the Ministry of Environmental Protection, and the Ministry of Housing, Urban and Rural Construction. We collect publicly available information from each regulator's website.

6.5. Results

We estimate the effect of the five types of regulatory announcements on the systematic risk of China's water industry using Equation (6.5) and report the results in Table 6.1. The results support our predictions that regulatory announcements that are expected to lead to decreased competition (COMP⁻), price change (PRICE⁺ & PRICE⁻), and increased quality of services (QUAL⁺) have significant impact on the

industry's systematic risk. The significant negative effect of $COMP^-$ suggests that when a regulator takes steps to reduce market competition, water companies are likely to gain greater power on the market, which in turn, results in higher price levels and profit margins. Subsequently, investors perceive reduced riskiness of the industry. As expected, the $PRICE^+$ group of announcements has a significantly negative impact on perceived systematic risk. It makes intuitive sense that when policy makers encourage water companies to set higher prices, the companies would have more success in covering their costs and making profits, leading to a perception of low risk level of the industry. On the other hand, the significantly positive effect of $PRICE^-$ indicates that when water companies' ability to adjust their own pricing policy is restricted by the authorities, investors become skeptical of the companies' profitability and require high returns to compensate for the high risk level. The positive sign of the quality coefficient ($QUAL^+$) means that the requirement to improve quality threshold of services increases the industry's systematic risk. Water industry is extremely capital intensive. Improving quality of services often involves large expenses in upgrading existing and/or investing in new tangible assets. This negatively affects returns and increases the riskiness of the companies.

Table 6.1 The effects of competition, pricing, and quality of service announcements on China's water industry's systematic risk without the controlling variables

Regressor		Coefficient	<i>t</i> -value	Adj. R ²
Constant	γ_0	0.804	(67.22)**	0.52
COMP ⁺	γ_1	0.011	(0.88)	
COMP ⁻	γ_2	-0.051	(-3.97)**	
PRICE ⁺	γ_3	-0.057	(-4.72)**	
PRICE ⁻	γ_4	0.032	(2.72)**	
QUAL ⁺	γ_5	0.035	(4.43)**	

Notes: ** indicates statistical significance at the 5% level. Robust standard errors are used in the calculation of *t*-values.

Though in the expected direction, the coefficient of increased competition (COMP⁺) does not reach statistical significance. This may be due to three reasons. First, as the most capital-intensive infrastructure industry, the entry threshold to the water market is remarkably high. New entrants are faced by many challenges at both financial and political levels, while existing water firms are in a strong position to compete. New private investors have limited options in the ways that they participate in the water industry and are most likely to enter the market by converting public water companies into joint stock companies (Pinsent Masons, 2004). The capital-intensive and monopolistic nature of the water industry means that investors would not be concerned about new players being invited into the water market due to governments' regulatory measures to enhance market competition. Hence, regulatory announcements that aim to increase competition may not be perceived by investors as damaging for the whole industry. Second, it is assumed that investors are typically more experienced with a competitive market than with a heavily regulated industry. Hence, they associate less uncertainty with regulatory

announcements that promote market competition (Antoniou & Pescetto, 1997). Lastly, creating an open market and enhancing competition has been a theme underlying China's water privatization. Regulatory announcements that emphasize market competition may be predictable or even expected by investors. Therefore, investors may be less sensitive to these announcements than to the other types of regulatory changes.

Following Pescetto (2008)'s method, the results presented in Table 6.1 only consider the effects of various types of regulatory announcements on the systematic risk of the water industry. However, in a real financial world, systematic risk is affected by other factors such as accounting variables; in fact, the accounting variables are commonly believed to be determinants of systematic risk (Chalmeau, 2013). To better observe the effect of regulatory announcements, we control financial leverage, operating efficiency, profitability, liquidity, and firm size. As reported in Table 6.2, three types of regulatory announcements – decreased competition ($COMP^-$), increased price ($PRICE^+$), and increased quality of services ($QUAL^+$) continue to show significant influence on the water industry's systematic risk, while the relationship between the increased competition ($COMP^+$) group of announcements and systematic risk remains insignificant. However, it is interesting that regulatory announcements that demand lower water prices ($PRICE^-$) no longer bear a significant association with systematic risk. This may be because water prices

in China have been very low and are markedly below the operational costs. The water industry still heavily relies on government subsidies. It has been the regulators' priority to introduce more aggressive pricing mechanisms in order to encourage preservation of water and to generate revenue to invest in water infrastructure and environmental protection. It is noteworthy that the water prices have been rising in the recent years and several government documents have been released to emphasize the necessity of this process (EU SME, 2013; OECD, 2009). Water investors interpret regulatory announcements that restrict higher profitability within this large political context and may not be particularly reactive to such news. Another possible explanation is that a low water price increases the barrier to entry, and this stabilizes water companies' returns and reduces the associated uncertainty. Hence, investors would not be particularly threatened by regulations that require companies to keep water prices/revenue low.

Table 6.2 The effects of competition, pricing, and quality of service announcements on China's water industry's systematic risk after controlling for the accounting variables

Regressor		Coefficient	t-value	Adj. R ²
Constant	γ_0	-0.557	(-14.61)**	0.61
COMP ⁺	γ_1	0.011	(0.95)	
COMP ⁻	γ_2	-0.025	(-2.03) **	
PRICE ⁺	γ_3	-0.043	(-4.12)**	
PRICE ⁻	γ_4	0.012	(1.15)	
QUAL ⁺	γ_5	0.020	(2.88)**	

Notes: **, * indicate statistical significance at the 5 and 10% levels, respectively. Robust standard errors are used in the calculation of t-values.

Overall, the results show that regulatory intervention efforts that aim to increase water prices (PRICE⁺) and improve quality of water services (QUAL⁺) significantly affect the industry's systematic risk at the 5% level, whether or not we control for the accounting variables. It is theorized that these two types of regulatory announcements are most in accordance with the stated main priorities of the government – raising water prices for financially and environmentally sustainable water infrastructure and providing better water and wastewater services to consumers (OECD, 2009). Given the repeated and reinforced messages from the regulators, investors tend to believe that regulatory announcements that allow higher water prices would subsidize their high costs for operation, increase profit margins, and reduce systematic risk. Similarly, announcements that require improved quality of services may lead to the belief that operational costs would surge due to greater environmental and quality obligations, making the water industry more risky. Investors have been more inclined to react to regulatory announcements that are consistent with the momentum of water reforms. In other words, the effect of regulatory intervention measures may be moderated by investors' perception of the overall political environment.

Table 6.3 presents the results from testing the effects of competition, pricing, and quality of service announcements on the systematic risk of each water company. It can be seen that when we do not control the unique characteristics (fixed effects)

of individual water companies as in the panel regression analyses, the regulatory announcements demonstrate mixed influences on the 19 sampled water companies. While announcements that are expected to decrease competition, increase water prices, and improve quality of services have a significant impact on the industry as a whole, this influence does not necessarily transfer to individual water companies. It is possible that due to the inconsistent and sometimes conflicting policies between central and local authorities (OECD, 2009), water companies are somewhat shielded from direct impact resulting from central policy changes. Moreover, Table 6.3 shows that most companies are significantly affected by two or fewer types of regulatory announcements, suggesting that investors consider the water industry as a very stable market with little uncertainty. In conclusion, regulatory risk should be perceived more as an industry-wide issue, and individual water companies are not easily threatened or benefited by regulation changes.

Table 6.3 The effects of competition, pricing, and quality of service announcements on the systematic risks of individual Chinese water companies

Regressor	β_1	β_2	β_3	β_4	β_5
COMP ⁺	η_1 0.081 (0.97)	-0.008	-0.015	-0.023	0.070
COMP ⁻	η_2 0.019 (0.97)	-0.005	0.037	0.041	-
PRICE ⁺	η_3 -0.058 (-2.43) ^{**}	-0.043	-0.036	-0.014	-0.269
PRICE ⁻	η_4 0.024 (0.56)	-0.003	-0.003	-0.007	-0.007
QUAL ⁺	η_5 0.013 (0.45)	0.010	-0.009	0.021	0.006
	β_6	β_7	β_8	β_9	β_{10}
COMP ⁺	η_1 0.001 (0.09)	-0.013	0.026	0.071	0.001
COMP ⁻	η_2 -0.040 (-1.67) [*]	0.018	-0.025	-0.074	-
PRICE ⁺	η_3 -0.025 (-1.93) [*]	-0.015	-0.079	-0.130	-
PRICE ⁻	η_4 -0.001 (-0.12)	-0.003	0.033	0.070	0.062
QUAL ⁺	η_5 0.013 (2.07) ^{**}	0.002	0.023	0.067	-0.026
	β_{11}	β_{12}	β_{13}	β_{14}	β_{15}
COMP ⁺	η_1 0.016 (1.24)	0.003	0.005	0.034	-0.012
COMP ⁻	η_2 -0.036 (-0.99)	-0.006	0.049	-0.039	0.016
PRICE ⁺	η_3 -0.029 (-2.34) ^{**}	-0.039	-0.038	-0.036	0.006
PRICE ⁻	η_4 -0.005 (-0.49)	0.031	0.029	-0.026	-0.021
QUAL ⁺	η_5 0.021 (1.84) [*]	0.005	-0.005	0.015	0.037
	β_{16}	β_{17}	β_{18}	β_{19}	
COMP ⁺	η_1 -0.026 (-1.21)	-0.010	-0.022	-0.018	
COMP ⁻	η_2 -0.007 (-0.27)	0.013	-0.028	-0.001	
PRICE ⁺	η_3 0.003 (0.09)	-0.026	-0.031	-0.038	
PRICE ⁻	η_4 0.018 (0.63)	0.014	0.013	-0.014	
QUAL ⁺	η_5 0.003 (0.15)	0.013	0.018	0.048	

Notes: **, * indicate statistical significance at the 5 and 10% levels, respectively. Robust standard errors are used in the calculation of t -values. $\beta_1, \dots, \beta_{19}$ denotes the systematic risk of Company Number 1 to 19. See Appendix 6.1 for a complete list of companies.

Table 6.4 provides insight into the regulatory intervention risk by revealing the overall impact of regulation on the industry's systematic risk. The coefficient of ANNO is found to be insignificant, suggesting that the regulatory announcements have no joint explanatory power on the systematic risk of China's water industry. Given our previous findings, this result is hardly surprising. The five types of regulatory announcement have shown diverging impacts on the industry's systematic risk. When we conduct an aggregated analysis, the effects naturally average each other out. Consistent with Antoniou and Pescetto (1997) and Pescetto (2008), we do not detect lower systematic risk being associated with regulation announcement events, failing to provide support to Peltzman's buffering effect theory.

Table 6.4 The overall effect of regulatory announcements on China's water industry's systematic risk

Regressor	Coefficient	<i>t</i> -value	Adj. R ²
Constant	-0.575	(-15.11)**	0.61
ANNO	0.006	(1.17)	

Notes: ** indicates statistical significance at the 5% level. Robust standard errors are used in the calculation of *t*-values.

6.6. Conclusions

China has initiated a movement of water industry privatization since the beginning of the 21st century. This has greatly shaped the landscape of China's water market. Being one of the three largest water markets in the world, China's private water sector serves the greatest number of consumers and is considered as a global and regional driver. Within this context, regulatory scrutiny and intervention plays an increasingly important role in the operation of water businesses and is recognized as a determinant of the performance of water industry. However, despite the urgent need for knowledge of regulatory risk in relation to China's water industry, no empirical effort has been made in this area. In fact, literature that explicitly examines the

riskiness of water regulation in a global context is also scarce. In order to address this research gap, this paper explores the impact of regulatory announcements on the systematic risk of China's water industry.

Our study sample is composed of 19 companies whose primary revenue is generated through providing water and/or wastewater services in China. We analyze the industry's regulatory risk by regressing their time-varying betas on different types of regulation announcement events. The results show that regulatory actions from China's central government do not have a significant impact on the systematic risk of the whole industry, failing to confirm Peltzman's buffering effect theory. However, the observation that regulatory announcements have no overall effect on the industry's systematic risk does not necessarily mean that the systematic risk is unaffected by regulatory efforts. The insignificant finding may be due to the effects of different types of regulatory announcements canceling each other out. When we classify the regulatory announcements into five groups, we find that regulatory announcements that are expected to reduce market competition, increase water prices, and improve quality of water services have a significant impact on the systematic risk of China's water industry before and after controlling for the accounting variables. However, regulatory efforts to enhance market competition and reduce water prices do not have significant associations with systematic risk. These findings partially support our hypothesis that regulatory announcement events affect water industry's systematic risk. They suggest that not all regulatory efforts can achieve the same effect on systematic risk. It is theorized that investors are not easily threatened by regulators' efforts to enhance market competition or reduce water prices possibly due to the unique characteristics of the industry, namely, high capital intensity, great

barrier to entry, and a desperate shortage of operating funding. Investors tend to be more responsive to regulatory efforts that are designed to reduce market competition, increase water prices, and improve quality of water services perhaps because these announcements are more in line with the monopolistic nature of the industry and government's stated priorities of efficient water services and consumption. Therefore, it is concluded that investors interpret regulatory announcements within a larger political environment and are more likely to perceive regulatory changes consistent with regulators' long-term objectives to be effective measures. Further analyses reveal that most individual water companies are not significantly affected by regulatory changes. This means that although investors view certain types of regulatory changes as being effective on the industry's systematic risk, their effects may not be transferrable at a company level.

Our study has several implications. Though regulatory announcements in general do not affect water industry's systematic risk, policy makers need to be aware of the potential outcomes of their actions. Specifically, their attempts to decrease market competition and increase water prices would reduce the perceived riskiness of water industry, while regulatory efforts to improve quality threshold of water services make the industry appear more risky to the investors. Moreover, it is important to remember that regulatory changes that have an impact at the industry level may not have the same effect at an individual company level. Our research is the first to look at a developing country's water industry's regulatory risk. More research in this field is urgently required. Future studies can investigate the underlying mechanisms of how regulatory changes affect individual companies, e.g., examining the role of local water authorities. Development of an overall index of regulation (such as the

‘Polynomics Regulation Index 2012’ for the telecommunication industry – a highly detailed measurement of regulation intensity) may alleviate some of the challenges in studying this highly defragmented industry.

Chapter 7 Conclusions

7.1. Summary

This thesis aims to understand the risks and returns associated with investing in the water industry – one of the largest industries in the world. The first study assesses the risk-adjusted returns on water stocks and analyses their relationships with the whole market as well as the diversification benefits of including water stocks as an alternative asset class. Studies Two and Three explore risk factors affecting returns on water stocks. Specifically, Study Two investigates the impact of asset liquidity risk on water companies' stock returns, while Study Three examines the effect of regulatory changes on China's water industry as a whole as well as on individual water companies.

The results of Study One

- show that the World Water Index – reflecting major movements of the water market – outperforms the traditional asset classes (i.e., stocks and bonds);
- indicate that the water sector has low correlations with the traditional asset classes and has the capacity to yield diversification effects in portfolios; and
- provide empirical evidence confirming the belief that the water sector can be used as an alternative investment asset class.

The results of Study Two

- suggest that asset illiquidity is positively associated with stock returns. Specifically, water firms with a larger proportion of illiquid assets-in-place are

observed to have greater stock returns than those with a smaller proportion of illiquidity assets; and

- support the notion that the irreversibility or illiquidity of assets-in-place produces a distinct effect in explaining water stock returns.

The results of Study Three

- demonstrate that regulatory announcements that are expected to reduce market competition, increase water prices, and improve quality of water services have significant impacts on the systematic risk of China's water industry;
- reveal that most individual water companies are not significantly affected by these announcements;
- imply that how regulatory changes affect the systematic risk may be dependent on investors' interpretation of a larger political environment; and
- suggest that there is no evidence supporting an overall regulatory intervention risk for the water industry.

This thesis clearly establishes the magnitude and significance of the water industry. It highlights the paucity in the research of the risk-return profile of water investments and illustrates the theoretical, practical, social and political needs for empirical work. The thesis has important implications for the management of water resources. It draws attention to the challenges associated with investigations in this highly fragmented yet heavily politicised industry and serves as a stepping stone for future research.

Currently, the global water industry is in need of huge amounts of investments if the severe shortage of water is to be addressed. Given the governments' financial constraints, private sector participation is urgently required in order to obtain the much desired financial resources necessary for building and upgrading water infrastructures, environmental protection, and providing safe and sanitary water to areas that are suffering from severe water stress (OECD, 2007; The World Bank, 2009). Despite the growing interest and need for knowledge on returns and risks in relation to the water market, little empirical research has been done. In particular, investment characteristics of the water industries in the emerging world are largely unknown. This research aims to address this imbalance. It is the first empirical effort to examine the impact of industry specific characteristics on water stock return and the first to explore a developing country's water industry's regulatory risk. It contributes to the literature by expanding our knowledge on the performance and diversification effects of water assets and by improving our understanding of water industry's systematic risk and regulatory effects.

The thesis summarises the different methods in participating in this booming industry and reviews the main research findings on the returns on water-related projects, stocks and derivatives as well as factors associated with the performances of water investments. It builds a new link between asset pricing theory and financial features and provides support for the investment irreversibility theory which contends that low reversibility of assets-in-place produces a distinct effect in explaining water stock returns.

If investors are to be enticed to participate in the water industry, they would need to understand the returns and risks that are associated with investments in the water industry. This research reassures investors that consistent with the investment community's common belief, water assets are valuable additions and can be included as an alternative investment asset class in their portfolios. A major risk that is inherent in this industry, by virtue of its being heavily infrastructure-based, is the so-called "illiquidity risk". The research verifies empirically the existence of asset illiquidity risk in water company stocks that cannot be explained by other factors affecting stock returns. It reveals the impact of regulatory systems on investors' cost of capital, economic viability of investment projects, and prices and yields of their shares. It concludes that water investors interpret regulatory announcements within a larger political environment and are more likely to perceive regulatory changes consistent with regulators' long-term objectives to be effective measures. Moreover, it finds that although investors view certain types of regulatory changes as being effective on water industry's systematic risk, their effects may not be transferrable at a company level.

The thesis highlights that if private sector investors are to be involved, policy makers must recognise that these investors do expect to be compensated for the illiquidity and regulatory risks, in addition to other non-diversifiable investment risks, that are inherent in the water industry. Moreover, it cautions policy makers to be aware of the potential outcomes of their actions. Specifically, their attempts to decrease market competition and increase water prices would reduce the perceived riskiness of water industry, while regulatory efforts to improve quality threshold of water services make the industry appear more risky to the investors. It is also

important to remember that regulatory changes that have an impact at the industry level may not have the same effect at an individual company level.

7.2. Future Directions

Despite the increasing interest in water investments, research is impeded by a lack of good, reliable market research data and intelligence on the water industry (Maxwell, 2011). This results from the challenges in defining the industry, drawing boundaries around the niche sectors, and estimating the market size and other characteristics (Maxwell, 2005). Researchers have not yet reached an agreement on the relative profitability in investing in regulated markets or the position of water assets in an investment portfolio (ASrIA, 2007; Robbins, 2003).

The study samples of the present thesis are comprised of stocks of listed water companies and do not include unlisted companies and funds. Therefore, they are not representative of the performance of the whole water market; the study results should be generalised with caution. Future research should look into the performances and investment characteristics of unlisted water companies and funds. The current research questions may be re-investigated using different datasets and sample periods.

The complexity of the water market and lack of reliable data makes it tricky to fit water assets into a portfolio (Dickinson, 2010). Researchers currently hold different views about their position in an investment portfolio: some see them as a commodity (e.g., Geman & Kanyinda, 2007), some believe that they may, to some extent, replace bonds (e.g., Boyer & Ciccone, 2009), and others consider them as equity investments. The thesis views water assets as an alternative investment class

and examines the equity features of water-related businesses. As the ongoing marketization of water resources, prospective studies should also consider the commodity features of water investments, especially young and maturing areas such as water (rights) trading and virtual water.

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Appendices

Appendix 5.1

List of Companies

Company Name	Market Value as of Jan 2012 (USD Thousands)	Country
Aalberts Industries NV	1,718,967	Netherlands
Aecom Technology Corp.	2,316,775	US
Andritz AG	4,432,933	Austria
Badger Meter Inc.	458,506	US
BWT AG	293,204	Austria
Compass Minerals Intl	2,281,143	US
Crane Co.	2,824,078	US
Danaher Corporation	33,828,410	US
Ebara Corp	1,450,826	Japan
Emerson Electric Co.	34,212,358	US
Energy Recovery Inc.	139,090	US
Flow International Corporation	165,358	US
Flowserve Corporation	5,232,728	US
Gorman-Rupp Co.	583,228	US
Halma PLC	1,933,259	UK
IDEX Corporation	3,012,304	US
Interpump Group	615,127	Italy
Israel Chemical Corp	5,073,345	Israel
ITT Corp	1,839,500	US
Lindsay Corp.	702,803	US
Mueller Industries, Inc.	1,474,714	US
Organo Corp.	440,157	Japan
Pall Corp.	6,733,767	US
Pentair Inc.	3,747,309	US
Pure Technologies Ltd.	120,821	Canada
Roper Industries, Inc.	8,639,811	US
Rotork	2,435,372	UK
Sulzer AG Reg	3,651,565	Switzerland
Toro Co.	1,835,971	US
Tri-Tech Holding Inc.	32,166	US
American States Water Co.	662,789	US
American Water Works Co.	3,827,851	US
Aqua America Inc.	3,095,867	US
Cadiz Inc.	119,262	US
California Water Service Group	770,582	US
China Everbright International Ltd.	1,423,564	China
China Water Industry Group Ltd.	21,552	China
Consolidated Water Co. Inc.	116,813	US
Hera SpA	1,599,226	Italy
Interchina Holdings Co. Ltd.	199,016	China
Metro Pacific Investments Corp.	1,774,669	Philippines
Pennon Group PLC	3,978,462	UK

Company Name (continued)	Market Value as of Jan 2012 (USD Thousands)	Country
Puncak Niaga Holdings Bhd	164,964	Malaysia
Severn Trent PLC	5,509,448	UK
SJW Corporation	447,117	US
Sound Global Ltd.	558,213	Singapore
Suez Environnement S.A.	6,117,689	France
Tianjin Capital Environmental Protection Group Co. Ltd.	1,168,534	China
United Envirotech Ltd.	119,510	Singapore
United Utilities Group PLC	6,418,792	UK
Veolia Environment S.A.	6,362,783	France
Ashland Inc.	4,600,683	US
Aegion Corp	600,279	US
Alfa Laval AB	8,028,124	Sweden
Fomento de Construc Y Contra	3,048,932	Spain
Geberit AG	7,412,881	Switzerland
Impregilo SpA Ord	1,196,419	Italy
Layne Christensen Co.	470,807	US
Mueller Water Products Inc.	383,328	US
Northwest Pipe Co.	206,592	US
Toto Ltd.	2,640,753	Japan
Uponor Oyj	678,596	Finland
Valmont Industries Inc.	2,268,744	US
Watts Water Technologies Inc.	1,358,962	US
Calgon Carbon Corp.	836,210	US
Beijing Enterprises Water Group Ltd.	2,051,952	China
Guangdong Investment Ltd.	4,010,842	China
Hyflux Ltd.	812,872	Singapore
Kemira Oyj	1,817,649	Finland
Kurita Water Industries Ltd.	3,291,868	Japan
Arcadis NV	1,131,239	Netherlands
Itron Inc.	1,429,150	US
Tetra Tech Inc.	1,382,555	US
Agilent Technologies, Inc.	12,316,297	US
IDEXX Laboratories, Inc.	4,327,895	US
Waters Corp.	7,380,766	US

Appendix 6.1

List of water companies

	Company	Timespan	Beta
No. 1	Anhui Grotong Hi-Tech Pipes Industry	2004 - 2013	0.649
No. 2	Anhui Water Resources	2003 - 2013	0.904
No. 3	Beijing Capital	2002 - 2013	0.872
No. 4	China Gezhouba Group	2002 - 2013	0.748
No. 5	Chongqing Water Group	2010 - 2013	0.903
No. 6	Fujian Zhangzhou Development	2002 - 2013	0.820
No. 7	Grandblue Environment	2002 - 2013	0.606
No. 8	Guangdong Golden Dragon Development	2002 - 2013	0.896
No. 9	Heilongjiang Interchina Water Treatment	2002 - 2013	0.233
No. 10	Jiangsu Jiangnan Water	2011 - 2013	0.543
No. 11	Jiangxi Hongcheng Waterworks	2004 - 2013	0.780
No. 12	Qianjiang Water Resources	2002 - 2013	0.859
No. 13	Shanghai Chengtou Holding	2002 - 2013	0.782
No. 14	Sichuan Guangan AAA Public	2004 - 2013	0.792
No. 15	Sound Environmental Resources	2002 - 2013	0.634
No. 16	Tianjin Capital Environmental Protection Group	2002 - 2013	0.820
No. 17	Wuhan Sanzhen Industry Holding	2002 - 2013	0.797
No. 18	Xinjiang Urban Construction Group	2003 - 2013	0.894
No. 19	Zhongshan Public Utilities Group	2002 - 2013	1.029

Notes: Beta is a constant figure calculated from Equation (1) $R_{it} = R_{ft} + \beta_i(R_{mt} - R_{ft}) + \varepsilon_{it}$. Ordinary Least Squares estimation is adopted.

Appendix 6.2

Frequency distribution table of the five types of regulatory announcements made by China's central water regulators: January 2002 – December 2013

Year	COMP ⁺	COMP ⁻	PRICE ⁺	PRICE ⁻	QUAL ⁺	Total
2002	1	2	3	-	-	6
2003	-	1	1	-	-	2
2004	2	-	-	-	-	2
2005	2	-	-	-	5	7
2006	2	1	1	1	3	8
2007	-	-	2	-	-	2
2008	-	2	2	-	-	4
2009	-	-	3	-	1	4
2010	1	-	1	2	-	4
2011	3	-	-	2	3	8
2012	1	-	-	-	4	5
2013	1	-	-	1	2	4
Total	13	6	13	6	18	56

Notes: COMP⁺ denotes announcements that are expected to have a positive effect on competition; COMP⁻ denotes announcements that are expected to have a negative effect on competition; PRICE⁺ denotes announcements that are expected to have a positive effect on prices; PRICE⁻ denotes announcements that are expected to have a negative effect on prices; and QUAL⁺ denotes announcements that are expected to have a positive effect on quality.

Appendix 6.3

Samples of regulatory announcements made by China's central water regulators: January 2002 – December 2013

-
- 1. Announcements that are expected to have a positive effect on competition (COMP⁺)**
 - May 19, 2009 (State Council) Fasten the reform of public utility services; expand the scope of business permits for water and wastewater services.
 - January 01, 2011 (State Council) Attract private funds by encouraging municipal-owned companies to invest in the water industry directly and indirectly.
 - 2. Announcements that are expected to have a negative effect on competition (COMP⁻)**
 - December 10, 2006 (Ministry of Water Resources) Water projects must be supervised and permitted by the Ministry of Water Resources and local water authorities.
 - April 9, 2008 (Ministry of Water Resources) The supply of water for any projects must be approved and implemented by relevant government bodies.
 - 3. Announcements that are expected to have a positive effect on prices (PRICE⁺)**
 - April 19, 2010 (Ministry of Development and Reform Commission) Develop a sustainable pricing mechanism by implementing hierarchical water prices.
 - August 31, 2011 (State Council) Promote hierarchical water prices; include additional wastewater costs in water tariff.
 - 4. Announcements that are expected to have a positive effect on prices (PRICE⁻)**
 - May 28, 2011 (State Council) Set reasonable water prices in the development of water grids in rural areas.
 - January 7, 2013 (Ministry of Development and Reform Commission & Ministry of Water Resources) Carefully and fully consider local economic development and consumers' ability to pay when setting water prices.
 - 5. Announcements that are expected to have a negative effect on quality (QUAL⁺)**
 - May 28, 2012 (Ministry of Housing, Urban, and Rural Construction) Apply stricter criteria to drinking water quality; drive higher standards; use more advanced technologies in drinking water treatment.
 - October 2, 2013 (State Council) Apply stricter standards in wastewater management; increase investments in the processing of wastewater.
-